New Scientist

WEEKLY 23 April 2022

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WE'RE LOOKING FOR THE *best ideas in the world* ON BEHALF OF OLDER PEOPLE

The Ryman Prize is an international award aimed at encouraging the best and brightest thinkers in the world to focus on ways to improve the health of older people.

The world's ageing population means that in some parts of the globe – including much of the Western world – the population aged 75+ is set to almost triple in the next 30 years.

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Since then world-leading researchers Professor Henry Brodaty, Professor Peter St George-Hyslop, Professor Takanori Shibata, Dr Michael Fehlings and Professor Miia Kivipelto have all won the prize for their outstanding work.

In 2021 Professor Kenneth Rockwood, a Canadian geriatrician, academic and anti-ageism campaigner whose research into frailty has had a huge impact, was awarded the prize by the Right Honourable, Jacinda Ardern, Prime Minister of New Zealand.

If you have a great idea or have achieved something remarkable like Kenneth and our six other prize winners, we would love to hear from you.

Entries for the 2022 Ryman Prize close at 5pm on Friday, July 15, 2022 (New Zealand time).

Go to **rymanprize.com** for more information.

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Academy

How to think critically and creatively

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academy.newscientist.com

Podcast

Weekly

This week, the team explore fresh attempts to send messages to aliens, and the controversy over whether we should include Earth's location. They also look at how bacteria-munching viruses can treat antibiotic-resistant acne and how we can teach ourselves to combat our biases. Plus, there is talk of self-aware monkeys and a 2000-year-old computer.

newscientist.com/nspod

RENE BECHARD/GETTY IMAGES

Tick-tock We can set, measure and understand time using physics

IRINA DMITRIENKO/ALAMY

Over here Should we include Earth's location in messages to aliens?

Video

Apollo 10½

Watch actor Jack Black and writer-director Richard Linklater talk about their new film, *Apollo 10½: A space age childhood,* which follows a young boy's fantasies about travelling to space, using beautiful rotoscoped animation to tell his story. Black and Linklater discuss the film and what it was like growing up in Houston, Texas, during the Apollo era.

youtube.com/newscientist

Newsletter

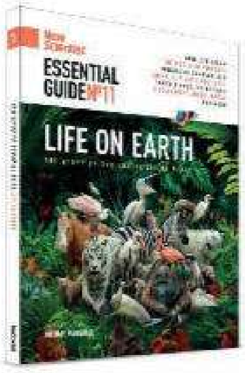
Health Check

Medical reporter Clare Wilson takes a critical look at the evidence suggesting that psychedelics such as psilocybin, the active ingredient in magic mushrooms, can treat otherwise untreatable depression and other mental health problems by "resetting" the brain.

newscientist.com/health-check

Podcast

> **"People are really upset at the idea that we're sending all this information to aliens"**



Essential guide

More than 3 billion years in the making, the latest *New Scientist Essential Guide* is a sweeping survey of the history of life on our planet, the wonders of biodiversity today – and the unique threats it faces from human activity.

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2021 TOP 10

Research beacons

GLOBAL CHALLENGES
MANCHESTER SOLUTIONS

Save our seas

Problems caused by our exploitation of the oceans need the same focus as on land

"HOW inappropriate to call this planet Earth when it is quite clearly Ocean". That quote, usually attributed to Arthur C. Clarke, pops up regularly at ocean science conferences, but is no less true for being a cliché. The ocean covers 71 per cent of the planet's surface and makes up 95 per cent of the area that is habitable by life.

Increasingly, it is being exploited by us. As our special report on what has been termed the "blue acceleration" details (see page 38), over the past 20 years, the ocean economy – fish, ships, hydrocarbons, wind energy, cables, tourism and more – has grown explosively. This trend is forecast to continue and the ocean is already feeling the strain. We are at risk of repeating the mistakes of our unsustainable exploitation of the land.

It isn't too late to drop anchor. Most of today's ocean economy is the definition of unsustainable, yet there are pathways to genuinely green growth driven by renewable energy, sustainable aquaculture and fisheries, and "blue carbon" – the capture of carbon dioxide by kelp, mangroves and plankton.

> "Decisions to be taken this year will be crucial for the future of the oceans"

But we must first stop degrading the ocean. That sounds like a whale of a task, and decisions this year will be crucial. At the fifth session of the UN Environment Assembly in Nairobi, Kenya, in February, Peter Thomson, the UN secretary-general's special envoy for the ocean, laid out six key waypoints, starting with that summit and ending with the COP27 climate conference in November. In between were final discussions over a new treaty for the high seas, negotiations to end harmful fishing subsidies, the agreement of new biodiversity targets and the UN Ocean Conference starting in June in Lisbon, Portugal.

The Nairobi meeting brought agreement to negotiate a treaty to tackle the scourge of oceanic plastic pollution. But the latest round of discussions on the high seas treaty broke up without a deal in March, with more talks planned for later this year.

The problems of the oceans are often overlooked in our focus on our depredations of the land. The global community must wake up to just how critical getting these agreements is for the water-world we stubbornly call Earth. ■

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AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

Changing medicine today.
Changing lives tomorrow.
medicalresearchfoundation.org.uk

"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

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Ancient black holes
How we might detect remnants of the early universe **p12**

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Amazon alert
Temperature swings warn of coming forest losses **p23**

JACK GUEZ/AFP VIA GETTY IMAGES

Pegasus spyware is made by the Israeli firm NSO Group

Cybersecurity

UK targeted by spyware

Researchers claim Pegasus software was used in cyberattacks against the prime minister's office, reports **Matthew Sparkes**

THE UK prime minister's office was targeted multiple times by spyware sold legally to states around the world, claim security experts. The Pegasus software, created by the Israeli firm NSO Group, allows security services to listen in to the microphone on a compromised smartphone, read messages and access sensitive data.

The Citizen Lab, a research group at the University of Toronto in Canada that has worked for years to examine the use of spyware such as Pegasus, claims that it warned the UK government of attacks in 2020 and 2021.

The group says it has found evidence for multiple suspected Pegasus infections of devices used by the prime minister's office and what was then the Foreign and Commonwealth Office (FCO), now the Foreign, Commonwealth and Development Office (FCDO). It claims that the spyware was being deployed against the FCO from the United Arab Emirates, India, Cyprus and Jordan, while the attacks against 10 Downing Street originated in the UAE.

Ron Deibert at the Citizen Lab said in a blog post that the group's main goal is to watch for spyware use against non-governmental organisations, such as charities and aid groups, but that it sometimes finds evidence of state-on-state espionage and would occasionally inform the targeted nation if it believed it could reduce harm to do so.

A report by *The New Yorker* claims that the UK National Cyber Security Centre scanned numerous devices used by Downing Street staff, including a smartphone used by Prime Minister Boris Johnson, once it had been informed of the attacks, but was unable to locate evidence of an intrusion. The report quotes a Citizen Lab member who believes data was probably stolen, and says that the UK has been "spectacularly burned".

NSO, which was founded by former Israeli state surveillance operators, says it licenses customers to use its software "only for their lawful and necessary purposes of preventing and investigating terrorism and serious crime". However, previous reports from the Citizen Lab revealed that Pegasus is being misused to watch journalists, academics and politicians.

Researchers have claimed that Pegasus has been used to hack the phones of journalists at Al Jazeera and Al Araby TV, as well as people at human rights organisation Amnesty International. In 2017, it emerged that Mexico had been using the software to target journalists and their families. It was also suspected in attacks targeting Amazon founder Jeff Bezos and associates of journalist Jamal Khashoggi, who was murdered in a Saudi Arabian consulate.

Jake Moore at internet security company ESET says that Pegasus and similar tools are often used by governments to carry out espionage against other states. It can infect users remotely, without their knowledge.

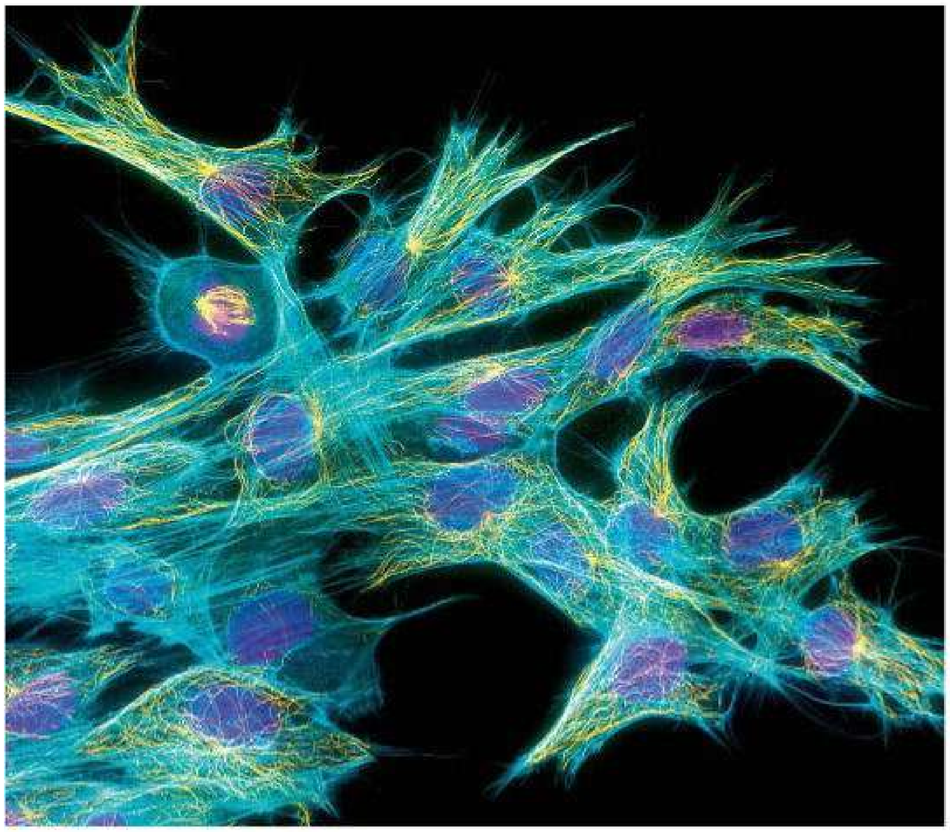
"Once the software is placed on a device, it can copy messages, view photos, record phone calls and even secretly view the user via the phone's camera, and both Android and Apple phones are vulnerable," he says. "Pegasus can be installed on phones via a simple text message or through exploiting vulnerabilities on devices that can even deploy without requiring the user to click anything. High-profile people must be aware of the ease at which this can occur and must take precautions such as using a second device for official business and hold private meetings away from any device where possible."

The FCDO and the prime minister's press office told *New Scientist* that they wouldn't comment on matters relating to security. NSO Group didn't respond to a request for comment. ■

Quantum physics

A quantum of consciousness

Experiments on tiny structures in brain cells bolster the idea that quantum effects might explain consciousness, finds **Thomas Lewton**



DR TORSTEN WITTMANN/SCIENCE PHOTO LIBRARY

Microtubules, seen in yellow in this image, are part of cell skeletons

THE controversial idea that quantum effects in the brain can explain consciousness has passed a key test. Experiments show that anaesthetic drugs reduce how long tiny structures found in brain cells can sustain suspected quantum excitations. Because anaesthetic switches consciousness on and off, the results may imply that these structures, called microtubules, are a nexus of our conscious experience.

According to some interpretations of quantum mechanics, a system can exist in multiple states simultaneously until the act of observing it distils the cloud of possibilities into a definite reality. Orchestrated objective reduction (Orch OR) theory postulates that brain microtubules are the place where gravitational instabilities in the structure of space-time break the delicate quantum superposition between particles, and this gives rise to consciousness.

Physicist Roger Penrose and anaesthesiologist Stuart Hameroff proposed Orch OR in the 1990s, but a lack of experimental evidence consigned it to the fringes of consciousness science. Some scientists regarded the theory as untestable, while others felt that the brain was too wet and warm to ever harbour these fragile quantum states.

Now, Jack Tuszynski at the University of Alberta in Canada and his colleagues have presented work at the Science of Consciousness conference in Tucson, Arizona, on 18 April, to challenge these convictions – showing that anaesthetic drugs shorten the time it takes for microtubules to re-emit trapped light. “It’s a major step in the right direction,” says Tuszynski.

“It is interesting,” says Vlatko Vedral, a quantum physicist at the University of Oxford. “But this connection with consciousness is a really long shot.”

Microtubules are hollow tubes made up of the tubulin protein that form part of the “skeletons” of plant and animal cells. Tuszynski and his colleagues shone blue light on microtubules and tubulin proteins. Over several minutes, they watched as light was caught in an energy trap inside the molecules and then re-emitted in a process called delayed luminescence, which Tuszynski suspects has a quantum origin.

> “It’s interesting, but this connection with consciousness is a really long shot”

It took hundreds of milliseconds for tubulin units to emit half of the light, and more than a second for microtubules. This is comparable to the time it takes the human brain to process information, implying that whatever is responsible for this delayed luminescence could also be invoked to explain the fundamental workings of the brain. “It’s quite mind-boggling,” says Tuszynski.

The team then repeated the experiment in the presence of anaesthetics and also an anticonvulsant drug for comparison. Only anaesthetic stifled the delayed luminescence, decreasing the time it takes by about a fifth. Tuszynski suspects that this might be all that is needed to switch consciousness off in the brain. If the brain exists at the threshold between the quantum and classical worlds, even a small suppression could prevent the brain from processing information.

In a second experiment, led by Gregory Scholes and Aarat Kalra at Princeton University, laser beams excited even smaller building blocks within tubulin in microtubules. The excitation diffused through microtubules far further than expected.

When Scholes and Kalra added anaesthetic into the mix, they also found that the unusual microtubule behaviour was suppressed. “The anaesthetic does interact with the microtubules and changes what happens. That is surprising,” says Scholes.

While this lends weight to the idea that microtubules control consciousness at the level of individual brain cells, Scholes stresses that further research is needed before conclusions about quantum effects are drawn.

The phenomena in the experiments could also be described by classical rather than quantum physics, says Vedral. “In these complex systems, it’s very hard to pin quantum effects down properly and to have a conclusive piece of evidence.”

Worth investigating

To sustain the theory, similar effects must also be demonstrated in living neurons and at temperatures found in the human body. Vedral says demonstrating that this happens in cells would be a “big deal”, whether or not it has anything to say about consciousness. “It’s certainly worth investigating. Even if you could claim that cell division is somehow underpinned by some quantum effects, this would be a huge thing for biology,” he says.

The remarkable characteristics of microtubules revealed in the experiments show that they are far more than just the scaffold of cells, says Scholes. “Nature is full of surprises. And if nature has some kind of structural framework, why not utilise it in more sophisticated ways than we’d think?” ▮

Transport

Driverless cars could be tricked into crashing

Matthew Sparkes

DRIVERLESS cars could be duped into interpreting a red traffic light as green, leaving them vulnerable to attacker-instigated crashes.

Although fully driverless cars aren't yet on the roads, there are already concerns that they may be more vulnerable to vandalism.

To learn more, Chen Yan at Zhejiang University in China and his colleagues tested if the cameras of different driverless models could be tricked into misinterpreting a traffic light.

The team aimed a laser at the sensors of five camera models used by such cars, with two open-source software packages interpreting the camera-captured images.

A laser with a wavelength of 650 nanometres introduced colour errors so that the entire image turned red, while a 520-nanometre wavelength gave the image a green hue. But neither fooled the cameras.

When flickering the laser at high frequencies, however, only certain parts of the image took on these colours. Adding a horizontal bar of green or red caused both software packages to incorrectly interpret the traffic lights as green 30 per cent of the time and red in 86 per cent of cases, on average across the five cameras (arxiv.org/abs/2204.02675).

The authors didn't respond to a request for comment, but suggest in their paper that redesigning driverless car cameras so they scan rows of pixels in a random order, rather than one row at a time, would make it harder for an attacker to introduce colour interference.

Richard Smith at De Montfort University in the UK says this research highlights the need for strong regulation of driverless cars, which aren't currently overseen by a global body.

"What needs to happen is autonomous vehicles need to be under as stringent guidelines as the airlines and aircraft manufacturers," he says. "If we don't have that, it's going to go badly, badly wrong. That's why studies like this are so good and so important, because they help to highlight potential issues that the car manufacturers need to be thinking about now."

The experiment required a lot of work to trick just one sensor, and driverless cars will hopefully have systems so their software doesn't rely on one camera alone. However, a determined attacker with enough resources "will always be able to make it go wrong", according to Smith. ▌

Driverless cars could be deceived into interpreting a red traffic light as green

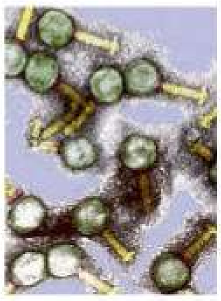
SHUTTERSTOCK/TEMP-64GTX

Health

Viruses help treat acne in mice

Michael Le Page

IT IS getting harder to treat acne because the bacterium that causes it is becoming increasingly resistant to antibiotics. However, adding viruses that kill this bacterium to acne treatments could restore their effectiveness, an animal study suggests.



SCIENCE PHOTO LIBRARY

Bacteriophages (yellow) are viruses that infect bacteria (green)

"I myself have suffered from acne," says Amit Rimon at the Israeli Phage Therapy Center, based at the Hebrew University of Jerusalem. "It might be cosmetic, but it can have a major psychological impact."

Certain strains of *Cutibacterium acnes* are thought to be the main cause of acne, often treated with antibiotics applied to the skin or swallowed as a pill, or both. But these standard treatments are becoming less effective as *C. acnes* gains resistance to these drugs.

So Rimon and his colleagues isolated eight different types of bacteriophages, viruses that infect and kill various types of bacteria. When a single type of phage was used to treat strains of *C. acnes* growing in culture, the bacteria sometimes developed resistance to the phage. However, when multiple types of phages were combined with antibiotics, they completely eradicated the antibiotic-resistant *C. acnes*.

Next, the team infected the skin of mice with *C. acnes* and showed that applying one of their phages to the skin resulted in improvements compared with controls (bioRxiv, doi.org/hp9v). The team thinks this is the first demonstration that applying phages to the skin can help treat *C. acnes*. They now hope to develop this into a treatment for people with acne, says Rimon. "We currently are trying to find investors and drug companies that are interested in taking phages to market."

The proportion of infections caused by antibiotic-resistant strains of *C. acnes* around the world is rising, says a spokesperson for the British Association of Dermatologists. In the UK, the level of resistance to various antibiotics ranges from 20 to 65 per cent.

The current guidelines are that antibiotics should be used judiciously for treating acne, but studies in the UK and US suggest that antibiotic usage is often excessive. Various alternatives to antibiotics are being explored, including preventing the inflammatory response triggered by *C. acnes* rather than tackling the bacterium itself.

"The proportion of infections caused by antibiotic-resistant strains of acne is rising"

Rimon says one of the reasons his team wants to develop a phage-based acne treatment is to pave the way for treating more serious infections. The phage centre has already helped to treat about 20 people with life-threatening infections, he says. In Israel, as in many countries, regulators allow the use of phage therapies only as a last resort when all conventional approaches have failed.

In Belgium, however, phage therapies are starting to be used more often thanks to a 2019 change in regulations specifically intended to make it easier for doctors to try this method. ▌

Palaeontology

Tiny structures in rock might be earliest known fossils of life on our planet

Carissa Wong

SMALL structures found in a rock that formed near a hydrothermal vent at least 3.75 billion years ago may represent the fossil remains of the earliest known life on Earth – but the findings are controversial.

Exactly when and how life emerged on Earth is widely debated. All we know is that it occurred sometime after Earth formed 4.5 billion years ago and before the earliest confirmed microbial fossils appeared around 3.4 billion years ago.

In 2017, Dominic Papineau at University College London and his colleagues analysed rocks collected from the coast of northern Quebec, Canada, in an area known as the Nuvvuagittuq Greenstone belt. By imaging sections of rock, the team found tiny tubes and filaments made of iron oxide, or rust, that resembled structures formed by bacteria that live in deep-sea hydrothermal vents today.

Now, the researchers have analysed a fist-sized rock from the same site by slicing it into pieces that are more than twice as thick as before – about 100 micrometres wide. This allowed them to get a bigger picture of the structures within the samples, which revealed a centimetre-long pattern of corkscrew-shaped iron filaments, arranged as a stem with parallel branches.

"The largest fossil in the rock is nearly a centimetre long and is organised in a structure that is tree-like. It's very beautiful because the structures are red in colour," says Papineau. "And those branching filaments are twisted like corkscrews, which has been thought of as a sign of life because [non-biological] processes are not known to make them."

Filaments in this rock might be the earliest signs of life on Earth

D.PAPINEAU

The tree-like pattern is surrounded by bubble-like ellipsoids that the researchers suggest could also be a result of microbial activity. But as these ellipsoids are known to sometimes result from certain types of non-biological chemical reaction, they call them dubiofossils (*Science Advances*, doi.org/hqcj).

"The paper provides one of the most comprehensive analyses I've seen of [supposed] microfossils in 3.75-billion-year-old rock," says David Emerson at the Bigelow Laboratory for Ocean Sciences in Maine.

But further work is needed to establish whether non-biological reactions could have produced the structures, says Emerson.

Others think a non-biological origin is more likely. They point out that the ancient rocks were buried deep in Earth's crust for some time, where they were baked at temperatures of over 500°C and exposed to pressures that might have created the filamentous structures through non-organic processes.

"I think that this is a very sound study, although I do not agree that the filamentous structures or the ellipsoids are fossil bacteria," says Frances Westall at the Centre for Molecular Biophysics in Orleans, France. But Westall doesn't rule out that life may have once lived in the ancient environment represented by the rock.

Archaeology

19th-century dairy farming women didn't breastfeed

WOMEN from a 19th-century farming community in the Netherlands probably didn't breastfeed their babies because they were too busy working. It is the first time that widespread alternative feeding has been discovered in a farming community from this period.

Andrea Waters-Rist at Western University in Canada and her colleagues analysed the bones of about 500 individuals who died between 1830 and 1867 in Middenbeemster, a rural village in the north of the Netherlands. The remains were dug up because a church was expanding into the cemetery, and Waters-Rist and her team were offered the chance to analyse them. They also had death certificates for about half the people.

The researchers wanted to find out more about the diets of the women and children in this village, which mainly consisted of dairy farmers at this time. They were able to determine whether the children were breastfed by analysing the chemical isotopes in their bones.

Out of 20 children who had died before the age of 1, 15 showed no evidence of breastfeeding. And out of 35 children aged between 1 and 6, 29 showed no signs of breastfeeding in their bones (*PLoS One*, doi.org/hqbv).

The team believes this was probably due to the fact that women predominantly worked the farms in this community, milking and raising the cows. "We think it's a sign of how hard the women were working and that they were just really busy," says Waters-Rist. "Also, there was always fresh cow's milk."

> "We think it's a sign of how hard the women were working and that they were just really busy"

This behaviour has only been seen in this period before in large cities where women were working in factories and couldn't take their babies with them, she adds.

"The findings of this study are intriguing for an agricultural community where mothers and infants would not have spent long periods apart," says Ellen Kendall at Durham University in the UK.

Jason Arunn Murugesu

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Botany

Lost flower rediscovered

The mignonette leek orchid was presumed extinct for almost a century

Alice Klein

A DELICATE, lemon-scented orchid species that was thought to have gone extinct after the 1930s has been rediscovered in south-east Australia.

***Prasophyllum morganii*, commonly known as the mignonette leek orchid, was first documented in 1929, but without further sightings since the 1930s, it was presumed extinct.**

Then, in 2020, after Australia's east coast was ravaged by the Black Summer wildfires, the Australian government funded detailed surveys of the burnt areas to find out which plants and animals were left. Four populations of orchids in New South Wales have been confirmed to be *P. morganii*.

"It's not often that you're able to come across something you thought was extinct, so it's really lovely," says Noushka Reiter at Royal Botanic Gardens Victoria in Melbourne.

TOBIAS HAYASHI, LA TROBE UNIVERSITY

Cosmology

How to spy the universe's first black holes

TINY, ancient black holes that may have formed in the early universe could help us uncover the internal structure of the densest stars. If they exist, these black holes could devour neutron stars from the inside, creating ripples in space-time called gravitational waves that we might be able to detect.

So-called primordial black holes are potentially important as an explanation for some of the effects of dark matter, but are predicted to be small, and so nearly impossible to directly detect. "An Earth-mass primordial black hole is only expected to have a radius of about 0.9 centimetres," says Yong-Feng Huang at Nanjing University in China. "You can imagine how hard it would be to detect such a small object that is completely black."

However, like any other object, some primordial black holes can at some point be expected to fall into stars. Huang and Ze-Cheng Zou, also at Nanjing University, calculated the effect on space-time if a primordial black hole fell into a neutron star.

They found that a black hole captured by a neutron star should quickly spiral towards the centre and swallow it from within. For a black hole with an initial mass similar to Earth's, this would take a little over 3 minutes. For a black hole about the mass of Jupiter, it would take only 0.2 seconds.

During this brief cosmic carnage, the motion of the black hole through the neutron star would send a unique pattern of gravitational waves propagating outwards across the universe. "This sort of gravitational wave emission can potentially help solve three fundamental issues in astrophysics: the existence of primordial black holes, the constitution of dark matter and the internal composition of neutron stars," says Huang.

"A primordial black hole captured by a neutron star should spiral to its centre and swallow it from inside"

The researchers have calculated that the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the US and its companion detector, Virgo in Italy, could potentially spot such gravitational waves from millions of light years away. Based on constraints on how common primordial black holes may be, it isn't surprising that one of these events hasn't been spotted yet.

"It would take 10,000 to 100,000 years for LIGO-Virgo to detect one such event. This is really very depressing," says Huang. However, more powerful future gravitational wave detectors might be able to find one after several years, he says.

Leah Crane

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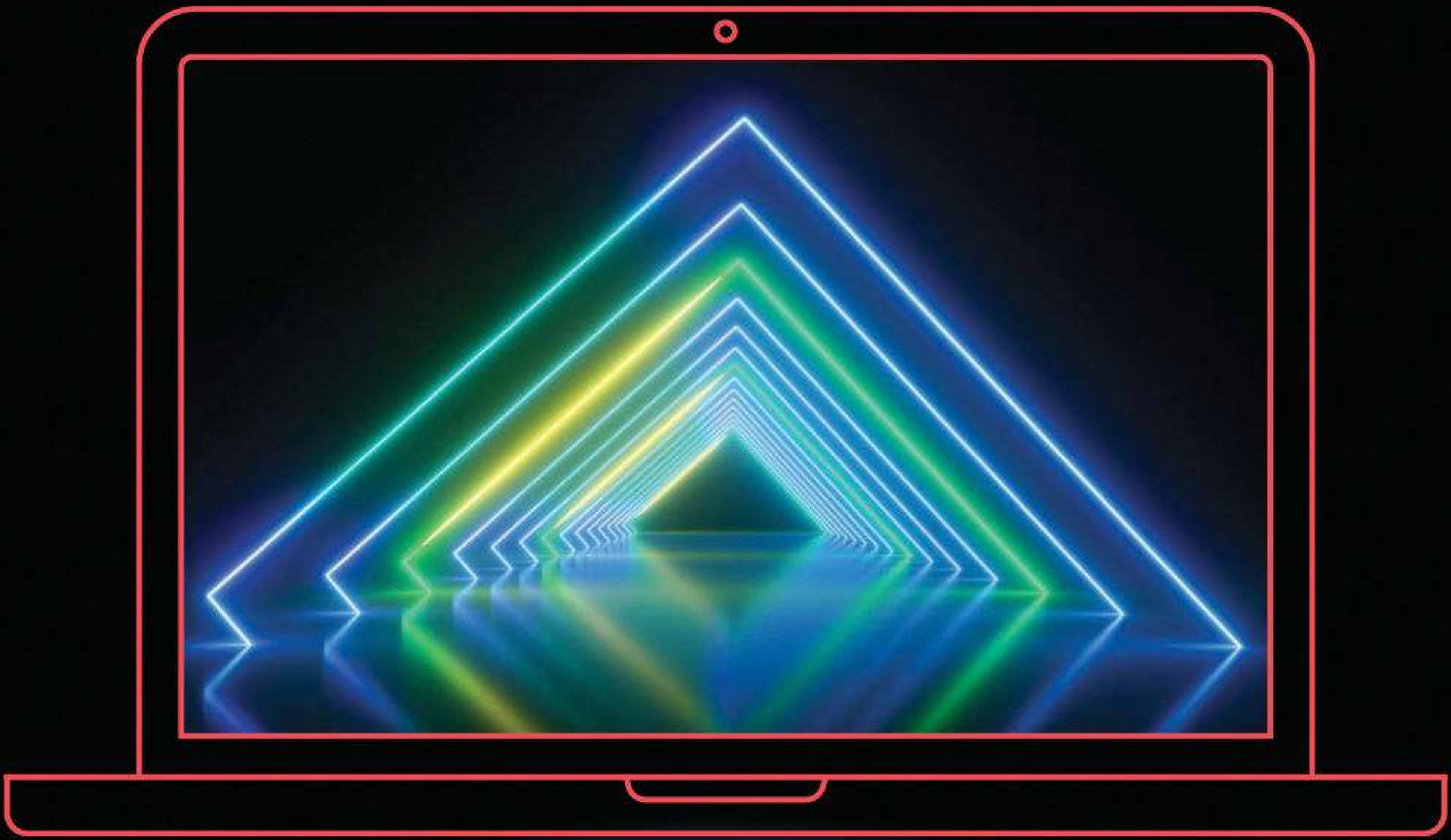

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Analysis Coronavirus

Is covid-19 causing diabetes? Many clinics are reporting people diagnosed with diabetes during or soon after an infection with the coronavirus – but the picture is complicated, reports Clare Wilson

COVID-19 is notorious for sometimes leaving an aftermath of puzzling symptoms, such as fatigue or concentration difficulties. But doctors are also worried about the coronavirus triggering a more familiar condition: diabetes.

In countries that are dropping coronavirus precautions, it seems likely that nearly everyone will get infected at some point. So what do we know so far about the link between the virus and diabetes – and how will health services cope?

Diabetes is an umbrella term for several conditions that involve high blood sugar, and can lead to serious complications, such as heart attacks. The body normally keeps blood sugar within a narrow window, as too high a level can damage organs and blood vessels.

The main hormone that brings down blood sugar into a safe range after meals is insulin. Nine in 10 people with diabetes have a form called type 2, which is usually seen in people who are overweight and is linked with cells becoming resistant to insulin. A less common form, called type 1, usually arises in childhood, and is caused by the death of pancreas cells that make insulin.

The strange thing with covid-19 is that doctors are seeing a rise in both kinds of diabetes after infections. Signs of a rise were noticed in the first few months of the pandemic in Wuhan, China, and have since been confirmed in other countries.

Most of the studies on this link so far have been descriptive ones, looking at people who go to hospital for covid-19 and are diagnosed with diabetes while there. More recently, researchers have begun estimating how often diabetes arises after the infection, including in people who didn't go to hospital, who account for most covid-19 cases.

A large US study published last month, for instance, estimated that anyone with a positive covid-19 test has about a 40 per cent higher chance of developing any kind of diabetes in the following year, compared with uninfected people. A similar German study found an increased risk for type 2 diabetes of 28 per cent over about four months. The picture for type 1 diabetes is less clear as some specialist clinics have reported rises in new diagnoses since the pandemic began, but not all have.

> **"The strange thing with covid-19 is that doctors are seeing a rise in type 1 and type 2 diabetes"**

There are several possible explanations for the pattern. Firstly, about 1 per cent of people in the UK are thought to have undiagnosed type 2 diabetes. If such people go to hospital because of covid-19 and their blood sugar is tested, the condition will be revealed, says Anna Morris at charity Diabetes UK.

Alternatively, many kinds of illness, including other viral infections, stress the body in various ways and so cause blood sugar levels to rise, a phenomenon called stress hypoglycaemia. "If someone's unwell, you get production of lots of hormones that raise glucose levels," says Ketan Dhatariya at Norfolk and Norwich University Hospitals NHS Foundation Trust, UK.

Once the illness resolves, the symptoms may abate, so in theory the diabetes diagnosis is only temporary, although those affected are at a higher risk of developing true type 2 diabetes later in life.

It is similar to the way that diabetes sometimes temporarily develops during pregnancy and then resolves after birth, although people are still at higher risk after, says Dhatariya.

Another possible mechanism is that the coronavirus could be directly infecting the cells in the pancreas that make insulin and harming or killing them. Some studies have shown that these cells have the ACE2 receptor that the virus uses to enter cells. Or the pancreas cells could be harmed by the raised level of inflammation caused by the immune system's response to the virus.

More than one of these explanations could be contributing to the apparent rise in new diabetes cases, says Kamlesh Khunti at Leicester General Hospital in the UK.

Confusing matters further, there have been some reports of people with signs of both type 1 and type 2 diabetes after a covid-19 infection. These include people who already had type 2 diabetes, but covid-19 seemed to trigger a syndrome called ketoacidosis, usually a hallmark of type 1 diabetes, says Francesco Rubino at King's College London.

Rubino's group has begun a global registry of people with diabetes related to the virus to try to understand the mechanisms involved and their prognosis. "We need to understand which [cases] could have occurred anyway and which were triggered by the virus," he says.

Diabetes healthcare services were already under pressure, with cases rising thanks to more people being overweight and individuals becoming more overweight. Any surge caused by the pandemic will only worsen problems, says Ziyad Al-Aly at VA St Louis Health Care System in Missouri, who was involved in the US study. "Even if only 1 or 2 per cent of people with covid develop it, the sheer colossal scale of the pandemic will mean millions of people will have new diabetes." ■

HORACIO VILLALOBOS/CORBIS VIA GETTY IMAGES

Blood glucose testing to screen for diabetes in Lisbon, Portugal

Psychology

People tend to believe populations are more diverse than they are

Jason Arunn Murugesu

PEOPLE may overestimate the presence of individuals from minority ethnic groups, even if they belong to those groups, which could create illusions of diversity.

"Individuals from the minority group are by definition less frequent," says Rasha Kardosh at the Hebrew University of Jerusalem in Israel. "Therefore, we are more likely to notice them and so are more likely to remember their presence, and so we end up overestimating their presence."

To investigate this overestimation, Kardosh and her colleagues carried out 12 psychological experiments with a total of 942 participants.

In one experiment, white people in the US were shown 100 faces, of which 25 per cent were Black people and the remaining 75 per cent were white, for 2 seconds. This was repeated 20 times with different sets of faces. The experiment was then carried out again, but this time 45 per cent of the faces were Black people and 55 per cent were white.

SHUTTERSTOCK/WILLIAM BARTON

Illusions of diversity can occur due to an overestimation bias

After both experiments, the participants were asked what percentage of faces they saw were of Black people, estimating 43 per cent for the first experiment and 58 per cent for the second.

The researchers then repeated both experiments with Black participants seeing the various faces, who estimated 43 per cent and 56 per cent of the faces were Black people in the first and second experiments, respectively.

"This [overestimation] is something that likely happens to most of us," says Kardosh. "Regardless of if you're in the minority or majority group."

In another experiment, 32 Jewish Israeli and 30 Palestinian Israeli students at the Hebrew University of Jerusalem were asked to estimate the number of Arab students at the university. The Jewish Israeli and Palestinian Israeli students estimated 31 per cent and 35 per cent, respectively, compared with the actual figure of 9 per cent (*PNAS*, doi.org/hqst).

Combining the 12 experiments, overestimation bias affected 82 per cent of the participants, regardless of their own ethnicity.

In another experiment, carried out on 100 students in the US, the participants who overestimated the presence of Black people in college programmes reported being less supportive of diversity-improving programmes when asked via a questionnaire.

Kardosh believes the main way to combat overestimation illusions is to improve the accessibility of diversity data. "Otherwise, people will be basing their decisions on biased impressions," she says.

Martijn Meeter at Free University Amsterdam says the experiments' results are unsurprising. "The main proposed mechanism is so much in line with what we know about memory that it is, in hindsight, hard to imagine why no one thought of [testing this experimentally] before," he says. "Indeed, the frequency of rare events are overestimated, that's why so many people are afraid of airplanes crashing – a vanishingly rare event." ▮

Particle physics

DNA-based device could precisely track subatomic particles

A DETECTOR consisting of a forest of DNA strands could tell us how subatomic particles move more accurately than existing devices.

The current best detectors can sense the mass of particles with high precision, but tracing the path that they take through one of the devices isn't always easy.

To address this, Ciaran O'Hare at the University of Sydney, Australia, and his colleagues have turned to a proposed DNA-based version. The idea, first put forward by another group of researchers in 2012, promises to allow physicists to track the path a particle takes with nanometre precision.

The detector would consist of a multitude of DNA strands hanging, like stalactites, above a collecting device. When a particle with enough energy crossed the detector, it would cut through several DNA strands at specific points along each strand's genetic sequence.

The severed lengths of DNA could then be collected, and O'Hare and his team propose analysing them to establish the exact point at which the DNA "stalactite" was cut.

Because the DNA molecule is so densely packed with genetic information, it would allow the severance point to be established to within nanometres. Doing the same thing for many of the DNA strands hit by a particle would give the ability to trace in three dimensions the path it took through the detector.

O'Hare and his colleagues have simulated this detector on computers using a simplified model without the collection apparatus (*The European Physical Journal C*, doi.org/hqch).

"For most particle types, you're able to tell the direction of movement really well with this"

"We were able to figure out that, for most different particle types, you're able to tell the direction of the particle really, really well, and that's all down to that nanoscale information [in the DNA]," he says.

The detector could trace the paths of particles for which direction of travel is a key piece of information, such as proposed candidates for dark matter, says O'Hare. ▮

Alex Wilkins

Plant pathology

Drones track disease in olive trees

High-tech tools will help monitor crops for infection with *Xylella fastidiosa*, a bacterium that has devastated the olive industry in southern Italy, reports **Priscille Biehlmann**

DRONES equipped with hyperspectral and thermal sensors will be deployed in Italy to spot trees infected with *Xylella fastidiosa*, a deadly bacterium that has been devastating the country's olive crops for almost a decade.

The sensors will be able to detect almost indiscernible signs of early infection, such as slight changes in the colour of leaves, allowing farmers to cull affected trees and prevent outbreaks. More than 300,000 trees will be examined using the new drone technology in the next few months.

"This technology has the potential to give the Italian government a major advantage in the fight against *Xylella*," says Manuela Matarrese at DTA, a research consortium involved in the project. "We tend to realise far too late if a plant is infected – these drone sensors will allow us to spot and prevent outbreaks rather than just react to them."

Early detection strategies like this are key for reining in *Xylella,* which is spread by spittlebugs that feed on infected plants, ingesting bacteria and passing them to healthy plants nearby. Once the bacteria have infected a plant, they block the xylem vessels that transport water through the plant, cutting off its ability to absorb water and, eventually, killing it.

"*Xylella* is particularly dangerous because it has many different natural hosts through which it can spread," says Andrea Maiorano, a plant health expert at the European Food Safety Authority in Italy. "There are hundreds of different plant species that can host it."

The first olive tree became infected in Italy in 2013, in the region of Puglia, on the southern edge of the country. Researchers now believe the bacterium arrived via ornamental coffee plants that entered Europe from abroad. Within two years, it had spread so rapidly that it threatened to destroy the entire region's livelihood. Millions of olive trees died and thousands more had to be culled to prevent further spread.

Xylella infection, also known as Pierce's disease, has now been detected in Corsica, mainland France, Spain and Portugal. It is estimated that it could cost the European Union up to €5.5 billion in lost crops.

In Puglia, which produces 40 per cent of Italy's olive oil, the impact has been devastating. Much of the southern part of the region has already lost the battle against the bacterium, with entire plantations wiped out – some of which were home to olive trees more than 1000 years old. The economic loss there has been estimated at €390 million.

Efforts are now concentrated on preventing the spread to the north of the region, where infections remain rare thanks to a strict containment strategy.

DIGICOMPHOTO/GETTY IMAGES

Leaves of an olive tree infected with *Xylella*

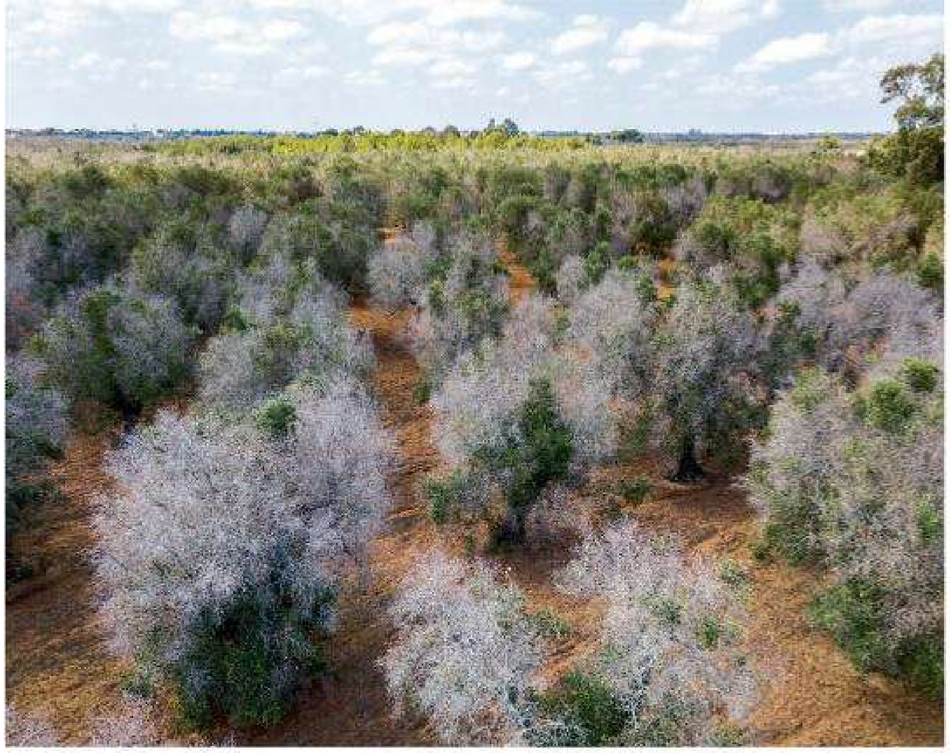
10%

of Italy's olive harvest has been lost to *Xylella*

€5.5bn

Potential cost of *Xylella* to the European Union

A drone's view of olive trees infected with *Xylella* in Puglia, Italy



LAVIO MASSARI/GETTY IMAGES

Under national legislation, as soon as a tree is found to be infected with *Xylella*, it must immediately be cut down – along with all vulnerable species within a 50-metre radius. A 2.5-kilometre zone around the infected plant is then closely monitored to prevent spread to surrounding trees. The remote-detection drones will ensure that any infected tree in these areas is diagnosed and culled quicker than ever before.

The hope is that this ruthless containment strategy in infected regions can buy time for the rest of the country's olive plantations until a cure can be found.

Search for a solution

Meanwhile, people are developing plant varieties that are resistant to infection. There is also research on treatments based on viruses that infect bacteria, called bacteriophages. A team at Texas A&M AgriLife in the US has developed a treatment that can be injected into infected trees, effectively killing the bacteria without harming the plant.

These possible solutions are still in the early stages. For now, containment is the best tool that farmers and governments have at their disposal to control the disease.

Salvatore Infantino, the head of agriculture of the regional government in Puglia, says the new early detection strategies are key. He hopes that the high costs paid in his region over the past decade can serve as a lesson for others in Italy and around Europe.

"As soon as you spot a case of the disease, you must act right away to eradicate it," he says. "In Puglia, this quick intervention didn't happen at first. And if you wait even a little bit, it's already too late." ▮

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Climate change

Carbon removal project in Iceland forced to adapt to punishing freeze

Adam Vaughan

THE world's biggest facility for removing carbon dioxide directly from the air is running behind schedule, after particularly taxing Arctic conditions froze machinery and forced the Swiss company behind it to make modifications.

Launched in September 2021, the Climeworks Orca plant to the east of Reykjavik in Iceland was hailed by the country's prime minister Katrín Jakobsdóttir as a "milestone in the fight against climate change".

> "The team knew Icelandic weather could be extreme, but the winter just gone was especially harsh"

The pioneering direct air capture (DAC) facility works by using geothermal energy to power fans that funnel air into collector units. Inside, a filter material absorbs CO_2 before it is released, piped and stored in basalt rock as calcium carbonate, permanently locking away the carbon.

Operations have been ramping up towards the plant's capacity of removing 4000 tonnes of CO_2 a year. But Christoph Beuttler at Climeworks tells *New Scientist* that this is taking longer than planned.

While the team knew Icelandic weather could be extreme, he says the winter just gone was especially harsh, with low temperatures stressing mechanical elements of the machines, including belt drives. "It's not high-tech stuff. We had to redesign parts of, not the core technology, but the technology around it, to adapt to the weather," says Beuttler.

The system is now working as expected, he adds. "It's a very good example of how important it is to deploy now and to get the experience."

An Intergovernmental Panel on Climate Change report released on 4 April highlighted DAC as a key tool for meeting the world's target of limiting global warming to 1.5°C, in tandem with rapid and deep emissions cuts. It also said the technology will need scaling up from the four-digit figure the Climeworks plant is aiming to capture each year to billions of tonnes if humanity isn't to overshoot its temperature goal.

CLIMEWORKS

Climeworks's Orca plant sucks carbon dioxide from the air

A spokesperson for Climeworks confirmed that it had faced "new challenges" due to "harsh climatic conditions", but didn't disclose exactly how many tonnes of CO_2 Orca is currently removing from the atmosphere. "We are slightly behind schedule," they say, adding that the plan was always for a gradual increase to full capacity by September 2023 at the latest.

Klaus Lackner at Arizona State University, who is one of the early pioneers of DAC techniques, says such teething troubles for a new technology should be expected. "The only way to learn about these problems and fix them is to try things out. Different climes will have different impacts. The other reason it is important is this is what brings the cost down," he says.

Climeworks is planning an even bigger project, called Mammoth, which would have 10 times the capacity of Orca, although its location is yet to be revealed.

Animal behaviour

Male toad clings to female for months for chance to mate

A SPECIES of endangered toad endemic to Colombia's Sierra Nevada de Santa Marta mountains is clinging on for dear life. A male Santa Marta harlequin toad (*Atelopus laetissimus*), which is typically just 4 centimetres long, can cling to the back of a female for five months without feeding until the pair are ready to mate.

The grasping behaviour, which is known as "amplexus", is seen in many other animal species – but rarely continues for such a long period of time, says Luis Alberto Rueda-Solano at the University of Magdalena, Colombia.

Rueda-Solano and his colleagues studied the toads in their natural environment to study the length of the amplexus. They were unable to track the toads for the entirety of the process, so estimated its duration based on weight lost during mating.

The research also showed that it is very difficult for a rival to dislodge a male grasping a female. Their strong hug has an average clasp force of 18.11 Newtons – equivalent to 52 times the male's body weight, according to the team's calculations. As well as using their tight grip to hold on, males fend off desperate challengers by kicking them away (*Animal Behaviour*, doi.org/hp7k).

MINDEN PICTURES/ALAMY

The Santa Marta harlequin toad (*Atelopus laetissimus*)

The Santa Marta harlequin toad probably developed its intense and protracted courting practices due to fierce competition, says Rueda-Solano. Males outnumber females three to one, so once a male sights a rare female, he is reluctant to let her out of his sight.

But clinging on for so long requires plenty of preparation. Males eat as much as they can to fatten up ahead of the mating season. They can expect to lose up to 30 per cent of their body mass while clinging to females, and some die from starvation while doing so.

Luke Taylor

Technology

Origami-inspired robot could deliver drugs in the body

Matthew Sparkes

A WIRELESS, origami-inspired robot could travel through the digestive system, releasing drug doses at the site they will be most effective.

Qiji Ze at Stanford University in California and his colleagues have built a 7.8-millimetre robot from polypropylene film that is just 0.05 millimetres thick. At each end is a thin magnetic plate that enables external magnetic fields to control the robot's movement.

Depending on the orientation of the fields, the robot can be made to spin, flip or roll through liquids, on solids and past any obstacles.

Like a concertina, the robot has a foldable shell that can be compressed. When exposed to certain magnetic fields, the plates at each end twist in opposite directions, collapsing the robot and releasing medicine from the shell.

In a lab experiment, the robot rolled and flipped along a set path in a stomach removed from a dead pig. Once at its destination, the robot was compressed using the magnetic fields to release medicine (arxiv.org/abs/2203.10122).

According to the Stanford team, the robot could be used for biopsies.

Shuhei Miyashita at the University of Sheffield, UK, says such technology is ready for real-world applications in humans, pending regulatory approval. "It's just a matter of people's decision whether, you know, they start using this technology for drug delivery or biopsies," he says. "I don't think technically there is a hurdle."

Space constraints mean robots smaller than 1 centimetre tend not to have electrical parts in them, says Miyashita. Magnetic steering will allow the Stanford robot's power, computation and control systems to be kept outside the body it is travelling through. This makes the robot inexpensive, small and disposable, with it passing through the digestive system naturally. ▮

Health

Transplanted immune cells show promise for multiple sclerosis

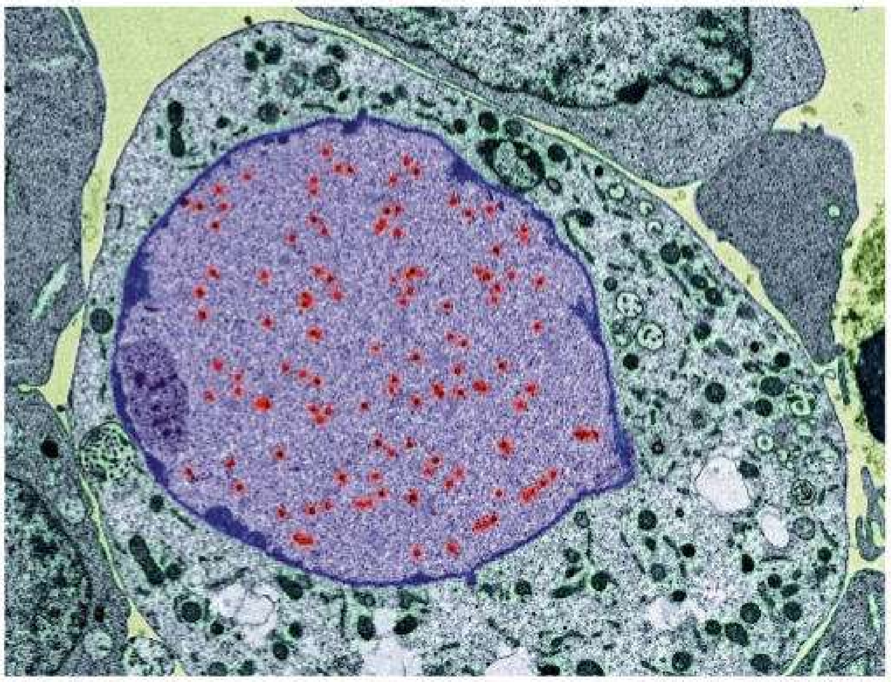
Michael Le Page

TRANSPLANTS of immune cells that target the Epstein-Barr virus have shown promise for treating multiple sclerosis in an early-stage trial. Brain scans suggest the progression of the condition was reversed in some participants, but this needs to be confirmed by larger trials.

Multiple sclerosis (MS) is caused by someone's own immune system attacking the myelin coating that helps nerve cells conduct signals, causing a range of symptoms from fatigue to difficulty walking. In most cases, people have relapses, suddenly getting worse but then gradually improving again.

In around 1 in 10 people with MS, symptoms get progressively worse with no relapses. While treatments can slow the course of relapsing MS, there are few treatments for progressive MS.

In an initial trial, US firm Atara Biotherapeutics gave 24 people with progressive MS injections of T-cells that seek out and destroy cells infected with the Epstein-Barr virus, the cause of glandular fever or mono. The T-cells were extracted from donors who had previously had an infection of Epstein-Barr virus, and were immunologically matched to avoid rejection.



Epstein-Barr virus (red) in the nucleus of a white blood cell

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

> "Recent studies have greatly strengthened the case that Epstein-Barr virus is a cause of MS"

In a presentation to investors on 22 March, Atara said that 20 of the people who received the injections saw their condition either stabilise or improve. The results were also previously presented at a conference.

The phase I trial didn't include a control group to rule out the placebo effect. But AJ Joshi, Atara's chief medical officer, says that, in addition to the effect on symptoms, MRI brain scans using a technique called Magnetisation Transfer Ratio (MTR) suggest that there was remyelination of nerve cells – that is, the myelin around them regrew to some extent.

Normally, MTR measures deteriorate in those with progressive MS, but MTR measures increased in those whose symptoms stabilised or improved, says Joshi.

The company is enrolling another 80 people in a phase II trial, the next step in the process of drug development in which a wider group receives treatment.

"It's encouraging that they've seen improvements in MTR," says Clare Walton at the Multiple Sclerosis Society UK. "But we've seen treatments look promising at phase I or even at phase II, but then, when you do the large, randomised trials, they don't show any outcome."

There is, however, a lot of excitement about treatments based on tackling the Epstein-Barr virus, says Walton, because recent studies have greatly strengthened the case that the virus is a cause of MS.

A study of 10 million military personnel in the US reported that infection with the virus preceded almost every case of MS. Another study showed that one of the proteins produced by the Epstein-Barr virus is very similar to a human protein made in the central nervous system, and that at least a fifth of people with MS have antibodies that bind to both proteins. In some people, the immune response to this viral protein may mistakenly target this human protein as well. The virus hides in people's bodies after the initial infection and sometimes reactivates, so this immune response can be continually stimulated.

If this is the case, tackling the virus should help treat all forms of MS. Atara chose to focus on progressive MS because there are few existing treatments, says Joshi. ▮

10 days | 10 June and 16 September 2022

Neanderthal Origins: Southern France

Step back in time on a journey to the key Neanderthal and Upper Palaeolithic sites between Bordeaux and Nice with Palaeolithic archaeologist and author Dr Rebecca Wragg Sykes. See some of the oldest traces left by archaic humans: stone tools, art objects, cave paintings and skeletons that have changed the way we think about Neanderthals.

While their fossils were first recognised some 160 years ago, until recently nobody knew whether Neanderthals had any culture or complex cognitive abilities. In this tour, Rebecca shows how advances in archaeological methods, especially over the past three decades, have transformed our understanding of these ancient ancestors.

Visit renowned archaeological sites and gain deep insights into the life and development of the Neanderthals, all while discovering the beautiful medieval towns and stunning countryside of the south of France.

Highlights

- Lectures and walking seminars throughout the tour from Dr Rebecca Wragg Sykes.
- Multiple archaeologically important caves and rock shelters including La Roche à Pierrot, La Madeleine, Le Moustier, Font-de-Gaume, Pech Merle, Grotte de la Baume Bonne and Grotte du Lazaret.
- Explore seven prehistory museums including the replica of the Chauvet cave.
- Visit scenic medieval towns and the seaside city of Nice.
- Enjoy stunning French countryside including the Tarn Gorge, Pont d'Arc rock arch and the Verdon and Grands Causses Regional Natural Parks.

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Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **The Word Forest Organisation**

The Word Forest Organisation

The secret to slowing climate chaos: tropical trees and supported communities

For the last 5 years, our international reforestation charity has worked with some amazing tree planting communities in rural Kenya. Together, we've created a blueprint to make our world well. It ensures the fast-growing trees we commission the planting of are nurtured and cared for to maturity. Our trees grow up to 10 times faster than anywhere else on the planet. On average, each one locks in around ¼ tonne of CO_2 so in terms of mitigating global warming, they're astonishingly efficient!

In return and by way of thanks, we pay a good and equitable wage to the people who tend the trees. We also provide a raft of humanitarian support designed to make communities more sustainable, more resilient and better equipped to face the challenging climatic conditions on the frontline of climate change, such as permaculture and organic growing workshops and lessons on how to extract commodities from living trees, like oil from the neem which the Mothers of the Forest turn into products that generate an income.

Women perform the lion's share of tree care. They also struggle to battle the bias in a predominantly patriarchal society. However, if we're to make swift environmental progress, conversations *must* involve men too, especially if we hope to tackle deforestation at its heart. Our Charcoal Burners Rehabilitation Programme is pioneering and progressive and it's open to all who want to change.

Word Forest never lowered its gaze through the pandemic, if anything, we upped our game and worked harder. We were fuelled by chilling news of climate-based human and wildlife death tolls and sobering statistics of species extinction, all silenced amid the noise of the new crisis. Following a debilitating 24 months for NGOs worldwide, we've made it out the other side. With your help, we could rinse and repeat what we know works well. Our recipe for success: caring for the people who care for the trees.

To see the positive impacts a donation, a legacy gift or a corporate partnership with us can have, watch our uplifting documentary #TreesAreTheKey narrated by Kate Winslet at TreesAreTheKey.com. Meet the incredible people who are cleaning the air we breathe all over the planet by planting trees in the tropics. Asante sana, marafiki: thank you, friends!

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Climate change

Temperature swings warn of coming forest losses in the Amazon

Alex Wilkins

AN EARLY warning sign for the loss of plants in the Amazon rainforest can be seen in the temperature difference between seasons, according to the latest climate models.

The sixth generation of these models, which were used to inform the 2021 climate reports from the Intergovernmental Panel on Climate Change, incorporates a wide range of data and environmental mechanisms. The models are the first to include dynamic vegetation, which looks at how plant populations change and interact over time.

Predicting forest dieback, where rainforest turns to savannah, is important because it could indicate when large volumes of carbon dioxide will be released into the atmosphere.

Isobel Parry at the University of Exeter, UK, and her colleagues used six of these models to predict how the Amazon will change in response to rising carbon dioxide levels and a warming climate. As well as finding evidence of forest dieback events in north-western Brazil, southern Colombia and northern Peru, Parry and her team noticed that a strong indicator of dieback events was when the gap between the highest and lowest annual temperatures in a certain region grew larger (arxiv.org/abs/2203.11744).

LUCAS NINNO/GETTY IMAGES

Forest fire smoke over a national park in the Brazilian Amazon

"The difference between those two [temperatures] is increasing before an abrupt shift [in vegetation]," says Parry. "This is significantly different from the sort of changes that you see at points that don't experience an abrupt shift, so it's a promising early warning signal."

"If you're starting to see the difference between the seasonal temperature difference between seasons, you may be at the edge of the cliff of an abrupt shift," says Carlos Nobre at the University of São Paulo, Brazil.

Given that the models don't take into account human-made drivers of deforestation, such as forest fires and land use changes, the levels of dieback could be even greater, says Nobre.

The signal could be particularly useful for monitoring areas of the Amazon that currently have good forest cover, such as the north-eastern Amazon and regions of Suriname and Guyana, he says.

> "This is the first time these climate models have predicted localised dieback events"

Some of the climate models that Parry and her team used also predicted localised dieback events, where certain areas in the northern region of South America appeared to show forest death. This is the first time that these climate models have predicted dieback events like these, says Parry.

Observations from satellite data have already shown that the Amazon has been becoming less green over the past two decades, which could be a sign that the region has become less able to restore itself to a stable state after being affected by events like wildfire or drought. ■

Evolution

Blind cavefish are developing local accents

IN THE underground caverns of north-eastern Mexico, groups of blind fish appear to be developing their own accents. The linguistic split could eventually contribute to ongoing speciation among the fish.

The Mexican tetra (*Astyanax mexicanus*) is no stranger to diversification. It exists in two forms: one with good vision that lives in light-drenched rivers, the other blind with a translucent body, which began evolving perhaps only 20,000 years ago as some fish populated dark caves.

Like many fish, *A. mexicanus* uses noise to communicate. It produces at least six distinct sounds for this, though their meaning seems to have shifted among the cave-dwellers as they adjusted to living in darkness.

Carole Hyacinthe at Harvard University wondered if the communication also varied between fish evolving in different caves.

Hyacinthe and her team analysed 44 hours of fish chatter recorded in six caves, spread across the three mountain ranges where cave colonisation is thought to have taken place independently. They compared a range of acoustic values in the fish noises, including the length of click, pitch and the rate at which multiple clicks were produced in sequence. They found several distinct variations between the caves. For instance, clicks were pitched relatively high in Molino cave, while they were deep and booming in Subterráneo cave (bioRxiv, doi.org/hp73).

LICKWINKEL/ALAMY

Some Mexican tetras (*Astyanax mexicanus*) live underground and are blind

This is probably the result of random genetic drift, says co-author Sylvie Rétaux at the University of Paris-Saclay. The team wonders if communication problems may see the fish split into distinct species. ■

Richard Kemeny

CYRIL RUOSO/NATUREPL.COM

Zoology

Monkeys have a human-like sense of their own heartbeat

RHESUS macaques appear to be as sensitive to their own heartbeats as human babies are, suggesting that the monkeys have an awareness of their own bodily systems.

The findings could open doors to a better understanding of some neurological and mental conditions in humans, says Eliza Bliss-Moreau at the University of California, Davis.

Sensing your heartbeat is part of interoception, the capacity to detect the internal state of your body. Previous studies have suggested that, at least in people, individual variations in our sensitivity to internal signals and how they are interpreted in the brain might be linked to our emotions, as well as to certain conditions, such as anxiety, depression and Alzheimer's disease.

Rhesus macaques (*Macaca mulatta*) have certain structures in the brain and nervous system that suggest they, too, are capable of interoception, but this hasn't previously been experimentally tested, says Bliss-Moreau.

She and her team came up with a way to do this after hearing of a study that found evidence human babies are sensitive to interoceptive signals. They monitored the heartbeat of four captive-born adult rhesus macaques while showing them videos of a blob-like image bouncing with a rhythm that was either slower, faster or the same as each monkey's heartbeat. Eye-tracking technology revealed that the monkeys watched the images for longer when the blob's beat was out of sync with their heartbeat – suggesting they found it surprising (*PNAS*, doi.org/hp7j).

Christa Lesté-Lasserre

Health

Meningitis vaccine cuts gonorrhoea rate

A VACCINE to prevent meningitis in young people also cuts the rate of the sexually transmitted infection (STI) gonorrhoea, which is caused by a related bacterium.

The effect is relatively modest, lowering rates of the STI by up to 40 per cent, but it could still be useful, as antibiotic-resistant cases are rising, says Helen Marshall at Women's and Children's Hospital in Adelaide, Australia.

Gonorrhoea can cause genital pain and discharge in women or men, but is symptomless in up to half of women with it and a 10th of men. Left untreated, it can cause infertility in women and blindness in babies born to infected mothers.

The STI is proving increasingly hard to treat because the bacteria are becoming more resistant to standard antibiotics. Even after successful treatment, people may get repeated reinfections. Some "super-gonorrhoea" strains are resistant to nearly all antibiotics.

The meningitis vaccine, called 4CMenB, was designed to target a bacterium called *Neisseria meningitidis*, which is a cause of brain infections, and is closely related to the gonorrhoea-causing *Neisseria gonorrhoeae*. Some of the antibodies generated by the meningitis vaccine bind to the gonorrhoea bacteria.

The 4CMenB vaccine was introduced in Australia for people aged between 17 and 20 in 2019. Marshall's team compared the rates of gonorrhoea in people who did or didn't get the vaccine. This showed that receiving the two required doses of the vaccine reduced the chances of getting gonorrhoea by 33 per cent (*Lancet Infectious Diseases*, doi.org/hp7q).

A similar study in the US, where the vaccine was introduced for 16 to 23-year-olds in New York and Philadelphia, found a 40 per cent cut (*Lancet Infectious Diseases*, doi.org/hp7r). **Clare Wilson**

Seismology

AI helps improve quake monitoring

A DEEP-LEARNING algorithm can remove urban background noise from tools that watch for earthquakes, potentially making it easier to pinpoint when and where a tremor occurs.

"Earthquake monitoring in urban settings is important because it helps us understand the fault systems that underlie vulnerable cities," says Gregory Baroza at Stanford University in California. "By seeing where the faults go, we can better anticipate earthquake events."

However, the sounds of cities – from cars, aircraft, helicopters and general hustle and bustle – adds noise that makes this difficult.

To try to improve matters, Baroza and his colleagues trained a deep neural network to distinguish earthquake signals in California from other noise sources. Around 80,000 samples of urban noise and 33,751 samples of earthquake signals were combined in different forms to train, validate and test the artificial neural network.

Running audio through the neural network improved the signal to noise ratio – the level of the signal you want to hear compared with the level of background noise – by an average of 15 decibels, three times the average of prior techniques that aimed to do this (*Science Advances*, DOI: 10.1126/sciadv.abl3564).

Chris Stokel-Walker

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Really brief

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A mutation makes Zika more virulent

The mosquito-borne Zika virus, which can lead to health problems in fetuses, becomes more dangerous if it picks up a single mutation, lab experiments with mice suggest. This version is also potentially more likely to pass from a mother to an unborn child (*Cell Reports*, doi.org/hp78).

Neptune cools despite summer

Summer on Neptune lasts for 40 Earth years, but although the planet's southern hemisphere has been experiencing summer for the past 15 years, it has cooled by 8°C. Why this is so is unclear, but it may relate to the atmospheric chemistry of this far-flung world (*Planetary Science Journal*, doi.org/hp5w).

Swifts enter torpor state on cold nights

When nesting, common swifts can lower their body temperature by 8.6°C and reduce their oxygen needs, entering a hibernation-like state called torpor. Doing so helps these birds save energy in harsh weather when there is little food available (*Biology Letters*, DOI: 10.1098/rsbl.20211.0675).

Astrophysics

Foam and laser help us probe star birth

SIMULATING clouds of gas in space with foam balls and laser beams is helping us figure out how supernovae can stimulate star formation. These small-scale experiments could deepen our understanding of the formation of our own solar system, which may have been born in such a cloud.

Physicists think that molecular clouds – clumps of gas and dust – can become stellar nurseries when they interact with shock waves from supernovae. In theory, the shock waves stretch and squeeze the gas and create dense areas that can collapse into stars. However, this is hard to study from afar and in computer simulations.

One solution is to build models of these systems. Bruno Albertazzi at the École Polytechnique in Paris and his team used a sphere of carbon-hydrogen foam about a millimetre across to represent the molecular cloud. They placed the sphere in a chamber with a small carbon pin, then fired a high-energy laser at the pin, rapidly heating it until it exploded. This sent a shock wave through the foam akin to that of a supernova.

The researchers analysed the foam ball to see if it ended up with any dense spots. These would represent areas in a molecular cloud that could then collapse in on themselves to form stars.

They found a small amount of compression, but saw 30 per cent more after two blasts instead of one. This suggests the process may be more important where there are lots of stars of the same age, and therefore lots of supernovae (*Matter and Radiation at Extremes*, doi.org/hp7w). **Leah Crane**

Food

KARL ALLGAEUER/ALAMY

This is why vegan sausages aren't quite like meaty ones

MIMICKING the mouth's mechanical properties in the lab helps explain why plant-based sausages don't quite feel the same as meat-based ones when you eat them.

Because of complex structures and compositions involved, working out how to make plant-based sausages more meat-like is hard.

To address this, Thomas Vilgis at the Max Planck Institute for Polymer Research in Germany and his team measured the physical properties of three types of sausage from the same manufacturer – one meat, one vegetarian and one plant-based. They applied a number of different mechanical forces to the sausage samples to simulate the mouth environment, such as compression, stretching and friction (*Physics of Fluids*, doi.org/hp7p).

They found the meat sausages slid more easily under friction than the plant and vegetarian versions, which he suggests is because the meat has more available fat that isn't bound up in the molecular structure. The meat sausages were also more elastic under compression because of different protein structures, says Vilgis.

These findings could lead to different ingredients being used in plant-based sausages to mimic such properties. Alex Wilkins

Physiology

Shoulder growth slows before birth

THE growth of a human fetus's collarbones slows just before birth, speeding up again during early childhood – probably an evolutionary compromise that allows our relatively wide shoulders to fit through the pelvis.

Broad shoulders may help with balance and our ability to throw, and might even help us breathe more effectively. But a fetus with broad shoulders poses a problem during childbirth because humans have a relatively narrow pelvis.

The slow-down-then-catch-up-later growth pattern in human clavicles – collarbones – around the time of birth appears to resolve this "shoulder mystery", says Naoki Morimoto at Kyoto University in Japan.

Morimoto and his team looked at CT scans of 81 humans, 64 chimpanzees (*Pan troglodytes*) and 31 Japanese macaques (*Macaca fuscata*). Chimpanzee collarbones showed a fairly steady growth rate from before to after birth, those of the macaques grew steadily before birth and then more slowly after birth. Growth of the human collarbones, however, slowed down about two months before birth and then sped up again over the next five years (*PNAS*, doi.org/hp72). **CLL**

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Comment

Do you hear what I hear?

We live in a world brimming with sonic wonders, but these riches are under assault. We need to listen, says **David George Haskell**

SIMONE ROTELLA

IN THE rainforest, thousands of species sing and call, forming acoustic layers so rich that the human mind can be overwhelmed. Drop a hydrophone into an ocean and you will hear similar richness, but made of sonic timbres alien to our air-adapted ears. Shrimp fizzle like cooking bacon fat, fish thrum and bleat and dolphins ping and chitter.

Hundreds of thousands of other vocal wonders ring out across the world. Every vocal species has a distinctive sound. Every place on the globe has a singular acoustic character.

This magnificence is of relatively recent origin. Compared with visual and chemical signals, the diversity of sounds flourished late on Earth. The keen ears of predators probably held back sonic evolution for hundreds of millions of years. But 300 million years ago, a few cricket-like insects and the ancestors of sturgeon and other fish started to sing. Sonic diversity has flourished ever since, spurred by the great advantages offered by vocal communication.

We live in a world of sonic wonder, yet this richness is being eroded worldwide. In oceans, forests and cities alike, sonic diversity is under assault.

In some places, sonic loss is caused by the destruction of habitats, from felled forests to overfished oceans. Elsewhere, noise is the problem. Machines pump so much sound into water and air that other species can't hear one another.

The problem of noise is most acute in the oceans, where seismic exploration, shipping and sonar create a cacophony so dire that it is uninhabitable, or nearly so, for many species.

In habitats such as dense rainforests or turbid oceans, sound is the only way for most animals to communicate even over short distances. This communication – mating songs, cooperative signals about food, cries that indicate social status and alarm calls – allows complex animal life to thrive.

In noisy or silenced ecosystems, the viability of species and communities is threatened. Sound connects animals to their mates, offspring and compatriots, and so noise can degrade the social and ecological networks of vocal species.

Sound and its diminishment also matter for practical reasons. As sound travels through dense vegetation or murky water, it gives us information about unseen or hard-to-measure trends in biodiversity. Land managers use the diversity of sounds in rainforests to rapidly assess the vitality and diversity of ecosystems. It would take decades to catch and identify every species, yet sound recordings capture some of the essence of biodiversity within hours.

Humans are also affected by environmental noise, with complaints about noise pollution dating to the very first cities, recorded on clay tablets from Babylonia. This noise is no mere inconvenience: its stresses create physiological burdens that sicken and kill. The European Environment Agency estimates that environmental noise in Europe causes 12,000 premature deaths and 48,000 new cases of ischaemic heart disease per year.

Sound gives us a tool to directly measure the environment. Documenting noise pollution means we can assess environmental harm and take steps to remediate environmental injustice.

What can be done to a ddress these problems? Perhaps amid the scientific studies of trends in sonic loss, activism to advocate for justice and policy-making to reduce noise pollution and habitat destruction, we might also find space to listen. Just as we go out with friends to hear a concert, might we do the same for the birds in a city park? In this simple act, we might find inspiration – and a direct connection to our more-than-human neighbours. ▮

David George Haskell is a biologist and author of *Sounds Wild and Broken*

No planet B

A small price to pay High-income nations must transfer some of their wealth to low-income ones to make amends for the damage they have done to the environment, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

THE country I live in is one of the richest on the planet, but also one of the poorest. By GDP, the UK is a superpower with the fifth largest economy in the world. But in terms of intact biodiversity, it is in the bottom 10 per cent globally and the worst in the G7.

These two facts aren't unrelated. The UK got rich – and has stayed rich – in no small part by overexploiting its natural resources. The agricultural and industrial revolutions turned great swathes of what was once green and pleasant into a polluted and overgrazed wasteland. Even today, more than two-thirds of the UK's land area is farmed and 8 per cent is built on, leaving little room for wildlife. The nation's Biodiversity Intactness Index (BII) – a measure of how much wild nature remains – is 53 per cent. The global average is 75 per cent. The ideal is 90 per cent plus.

That pathway to riches is one that many less-wealthy countries aspire to. But it is also a pathway to mutually assured destruction. A global BII comparable with the UK's would be catastrophic.

Preventing nature-rich countries from trashing their biodiversity is, of course, one of the goals of the UN Convention on Biological Diversity (CBD), over which the latest round of negotiations took place in Geneva last month. Such talks naturally feature conservation targets, habitat restoration and so on. But they actually revolve around something else: money.

Before the meeting began, I spoke to conservation biologists about what to look out for. One of them, Stephen Woodley at the International Union for Conservation of Nature, told me bluntly: "It's all about the money."

Biodiverse countries are often GDP-poor, and many don't see why they should be forced to remain so in order to rescue wealthy nations from catastrophe. And even where there is the will to preserve, countries often lack the necessary resources and need financial help. "The big issue is about wealth transfer," Woodley told me. "I suspect that the negotiations will hinge on that."

He was right. There were many sticking points, but by far the stickiest was finance. Reports from the meeting say that the spirit of the talks was mean, with negotiators generally putting national interests first. For rich countries, that meant digging their heels in over the payments.

> **"The US and Europe are responsible for more than half of global ecological destruction over the past 50 years"**

If anything, the negotiations went backwards. The draft text at the start of the meeting included concrete figures, such as that lower-income nations should be given an extra $10 billion every year for conservation. By the end of the talks, all of those numbers had disappeared, replaced by a dog's breakfast of watered-down and disputed suggestions.

This isn't just greedy and immoral in the here and now. There is also a historical obligation for richer countries to transfer some of their vast and ill-gotten wealth to poorer ones, to compensate them for the damage they have done to the environment. A recent analysis published in *The Lancet Planetary Health* found that the US and Europe are responsible for more than half of global ecological destruction over the past 50 years. Other wealthy countries, including Australia, Canada, Japan and Saudi Arabia, are collectively responsible for another quarter, while the low and middle-income countries of Latin America, Africa and Asia are responsible for just 8 per cent.

Alongside greed, immorality and injustice, we can add short-sightedness. "We will pay this amount of money, either today, or we will pay substantially more later on in lost ecosystem services, clean water, clean air, pollination, all these things that we take for granted," says Brian O'Donnell at the Campaign for Nature, an alliance of more than 100 conservation organisations. "If we destroy the ecosystems we rely on, the cost will be astronomical."

This is depressingly familiar from climate talks. In 2015, wealthy nations promised to donate billions to lower-income ones to help them mitigate climate change and adapt, but have yet to cough up. They cynically stamp out attempts to extract compensation for "loss and damage", apparently frit that this would be seen as an admission of guilt and open the floodgates to reparation claims.

There is hope. The clean text that the talks opened with was an ideal one drawn up by the CBD; the mess that emerged is a work in progress by the people who wield actual power. There is a history of brinkmanship at such talks and the CBD itself said that progress had been made.

And while countries like the UK will never accept that much of their wealth is an ecological overdraft that is now overdue, they are starting to understand that they have no option but to pay. "I think governments are starting to recognise that this is an investment rather than just a cost," says O'Donnell. ▮

Graham's week

What I'm reading

The Age of Extremes: The short twentieth century, 1914–1991 *by Eric Hobsbawm. Suddenly very relevant again*

What I'm watching

Dinosaurs: The final day with David Attenborough *on the BBC. Attenborough does it again.*

What I'm working on

Whether to get a new cat. The old one sadly joined his younger companion.

This column appears monthly. Up next week: Annalee Newitz

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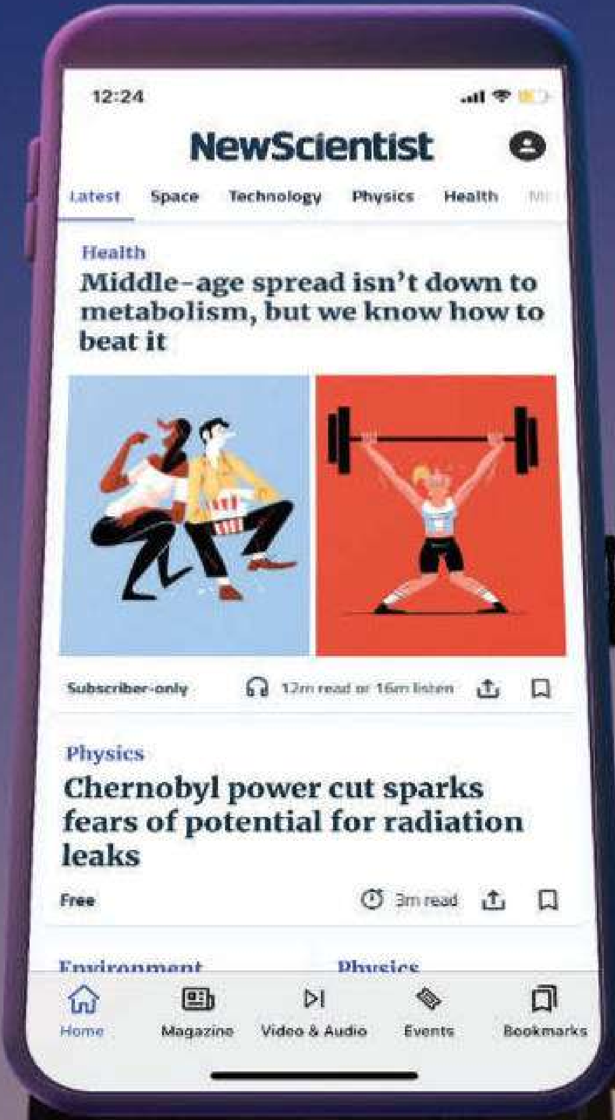

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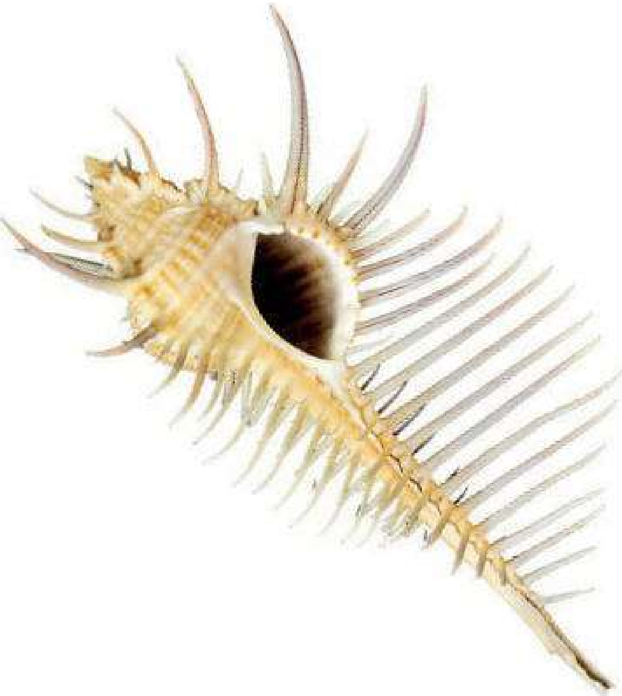

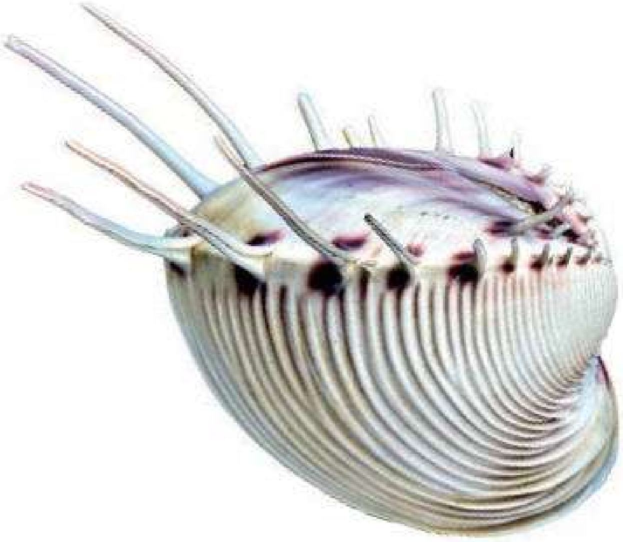

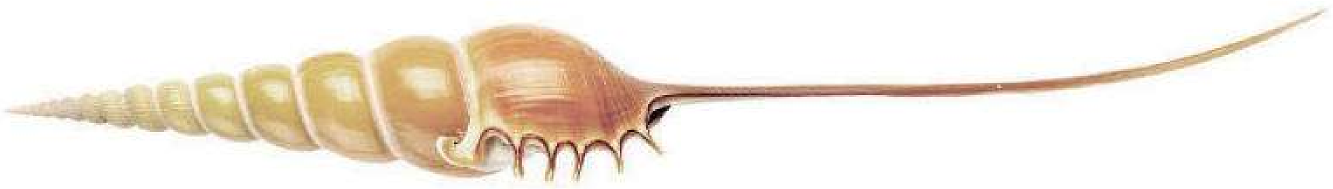

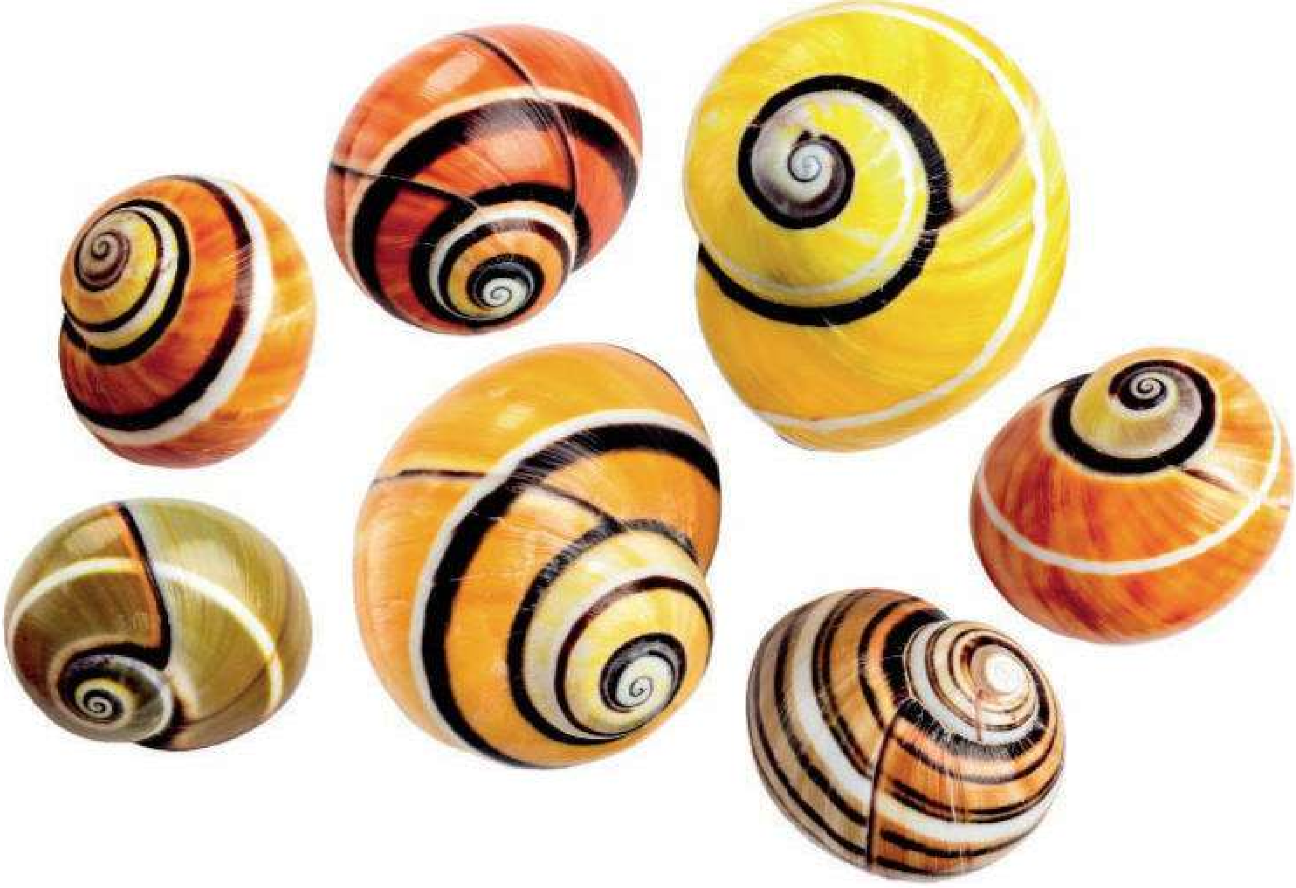

Fragile beauty

Photographer Kevin Webb

THE fascinating diversity of mollusc shells is showcased in these striking photographs of part of the shell collection at the Natural History Museum in London. The images are taken from *Interesting Shells*, a new book by Andreia Salvador, senior curator of Marine Mollusca at the museum. Containing more than 8 million specimens, the museum's shell collection is one of the largest in the world.

Molluscs are invertebrates – soft-bodied animals without an internal skeleton – and include snails, oysters and cuttlefish, as well as some organisms that don't have a visible shell at all, like slugs. They can range in size from snails less than 2 millimetres long to giant squid, which can reach 13 metres in length, writes Salvador.

The top row of images shows (left to right): the shells of a Venus comb sea snail, an episcopal mitre sea snail, a marbled cone sea snail, a spiny Venus clam and a Lazarus jewel box clam.

The photo at middle right shows a shinbone tibia gastropod, another species of sea snail.

The bottom row of images shows (left to right): the shell of a green tree snail, West Indian worm shells and Cuban land snails.

These hard exoskeletons in the images are used as protection against the environment and predators. The shells are made of calcium carbonate and a protein called conchiolin, which, as Salvador writes, are secreted by the mantle, a layer of tissue covering the soft parts of the body. As the mollusc grows, new shell is secreted, making more room for the animal. ▮

Gege Li

ALL IMAGES ©THE TRUSTEES OF THE NATURAL HISTORY MUSEUM, LONDON

Editor's pick

Is this why bioscience has a replication issue?

9 April, p 45

From Dave Smith,
Alnwick, Northumberland, UK

While the points made in "Failure to replicate" are all reasonable, there is a potentially valuable explanation for seemingly unreproducible experiments: an additional factor that hasn't been controlled for.

For example, when researchers were faced with different results from genetically identical mice obtained from different suppliers, patient detective work led them to a missing ingredient in the microbiomes of one of the line of mice. Interestingly, not only is the microbiome of people very variable, but so, too, is that of their cancers.

Soil has huge potential to help us tame climate crisis

9 April, p 8

From Cheryl Hillier,
Lampeter, Ceredigion, UK

When it comes to ways to avert a climate crisis, we rarely hear about the capability of soils to sequester carbon, which far outstrips any technological "fixes" that are still largely hypothetical to date in terms of cost, feasibility, speed, simplicity and scale.

It seems that a global increase of organic matter in soil of just a few percentage points would be sufficient to make a real difference by reducing carbon dioxide levels in the atmosphere, helping us confront global warming.

On the pros and cons of a zero-covid approach

2 April, p 27

From Peter Sutton,
Guildford, Surrey, UK

I agree with much of the logic in Michael Marshall's appraisal of zero-covid policies. With no vaccines, governments and health bodies were right to attempt to limit covid-19 in 2020.

However, it isn't clear how long one needs to persist with a zero-covid strategy – three months, 30 months, 300 months? It is crucial to set end points. Marshall also states that a successful zero-covid policy would mean omicron probably wouldn't have evolved. This implies that a less damaging, more contagious variant is bad. Right now, most people see omicron as a good development.

From Tom Jones,
St Austell, Cornwall, UK

You compare New Zealand and Vietnam with the UK. However, the UK has a huge proportion of non-UK citizens who want to be able to visit or be visited by relatives living abroad. Also, a large proportion of the UK population is abroad at any given time. They would be stuck there if there was a zero-covid policy.

The UK is also a leading international hub for air travel, far more so than New Zealand, Australia and Vietnam. Finally, China is finding a zero-covid approach is beginning to fail amid new subvariants.

Let's not get bogged down in consciousness problem

2 April, p 38

From John Cantellow, Derby, UK

"Trying to reformulate physics to include subjective experience as a physical constituent of the world", as the article by Thomas Lewton puts it, seems unlikely to succeed.

If we were to look inside our heads while enjoying our rich, subjective experience, we would see none of it. It doesn't physically exist; just as the emperor's new clothes didn't physically exist.

In any event, physics already allows for a non-physical domain. It is where virtual particles are to be found when they aren't physically in existence.

From Lawrence R. Bernstein,
Menlo Park, California, US

Proposed connections between consciousness and quantum physics seem based on little more than both appearing mysterious, hard to fathom and a bit spooky. Imaginative humans can project consciousness into disembodied spirits, trees, rocks, quarks and the big bang, but there is no evidence for it originating or extending anywhere outside of a brain.

Charades is a fine way to communicate abroad

26 March, p 38

From Alan Stennett,
Sydney, Australia

The idea in "Playing with words" that our language abilities evolved and developed thanks to charades-like exchanges struck a chord.

Like a lot of monolingual English speakers, I get by abroad with some basic French learned at school and a smattering of greetings in other languages. It is one of the rewards of international travel when you succeed in communicating at a level of common humanity. There is the stimulating buzz of improvisation using sign language, body language and lots of goodwill.

Claws out for idea of gene-edited hypoallergenic cats

2 April, p 9

From Anne Ryder, London, UK

I object to the idea of using CRISPR gene editing "to make hypoallergenic cats" and some of the language used to describe this. You can't "make" cats, as cats aren't objects; they are creatures made via evolutionary nature, influenced by breeding. No one has the right to alter genes to see how a cat will survive if it can't produce the Fel d 1 protein, the main cause of allergic reactions to these pets in people. I'm allergic to them myself, yet have had beautiful cats as pets.

Earlier work paid tribute to science beyond Europe

26 March, p 27

From Dave Holtum,
Bathampton, Somerset, UK

James Poskett says that the debt owed by science to non-European scientists of yesteryear has been largely ignored until the past decade. However, *The Cambridge Illustrated History of the World's Science*, published some 40 years ago, devotes about half of its pages to Greek, Arabian, Hindu and Chinese science before 1500 and shows how Muslim scientists kept science alive from about AD 800.

Did rats really need to be used in study of stroking?

19 March, p 46

From Ingrid Newkirk,
People for the Ethical Treatment of Animals, Washington DC, US

Regarding the "Emotional touch" part of your look at chemical haptics, and the "mild stress" inflicted on rats for a study. Surely it wouldn't have been hard to find students mildly stressed by exams or something similar who didn't mind being stroked beforehand to test the ideas being considered. Instead, the default was to grab some (no doubt already stressed) rats. It is time such malarkey stopped.

For the record

- **Satellites reveal information on Earth's magnetic field more than 3000 kilometres below our feet (26 March, p 12).**
- **The image in our article on resurrecting extinct species was actually of Lumut Port in Malaysia (19 March, p 23).**

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PML | Plymouth Marine Laboratory

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Digital science roles to transform marine science

Could you be part of an ambitious team seeking to harness the full potential of AI, machine learning and autonomy in support of a sustainable ocean future? Plymouth Marine Laboratory (PML) is a world-leading marine research charity, committed to the pursuit of research excellence to support our vision of a healthy and sustainable ocean.

Our papers are amongst the top 1% of the most-cited environmental science papers in the world and we have a track record of delivering meaningful, impactful science which has helped shape UK and international policy on critical subjects such as climate change, marine plastics and biodiversity. Artificial Intelligence (AI), Machine Learning (ML) and autonomy are emerging as important research tools, with the potential to be applied across many aspects of our work and unlock exciting opportunities to expand the horizons of marine research.

Lead for Environmental Digital Science £55k - £65K pa

Tasked with shaping and delivering PML's Digital Science Strategy you will provide lab-wide strategic leadership to facilitate digital transformation across all science areas, mentoring colleagues and enabling PML to fully embrace a Big Data future and capitalise on digital tools and techniques such as AI and Machine Learning.

As a senior leader with proficiency working with large datasets or synthesis within your research (using a range of coding, data formatting and manipulation techniques), you will ensure the opportunities provided by advanced digital science techniques are exploited in order to deliver and publish world-class marine environmental and social research.

Essential requirements:

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- Demonstrable understanding of the tools and infrastructure required for carrying out digital-centric research (coding; data formatting and manipulation)
- Experience in securing external funding to support research activities, training and capital infrastructure investment
- Ability to demonstrate the interoperability between the different datasets which form the PML data ecosystem and data ecosystems held elsewhere.

To discuss the role in more detail please contact Steve Widdicombe, swi@pml.ac.uk

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We are looking for biogeochemists, ecologists and social scientists with digital skills to help drive PML's digital strategy forward. Using digital technologies and advanced techniques to carry out and publish world-class marine environmental and social interdisciplinary research, you will inform some of the most significant global environmental challenges while helping to build knowledge across the organisation.

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- A track record of securing research funding
- Experience of conducting social or natural science within an interdisciplinary setting.

To discuss the role in more detail please contact Steve Widdicombe, swi@pml.ac.uk

Data Systems Architect £32,527 - £38,486 pa

Supporting the implementation of advanced digital science and data manipulation techniques within PML, you will play a key role in developing and growing the PML data ecosystem, using your understanding of how datasets can be used, visualised and re-purposed to support new scientific discovery and world-class research.

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Essential requirements:

- Experience of designing the flow, exchange and interchange of Big Data within a research environment
- Understanding of the purpose and value of datasets and how to determine the most suitable format of data to use for a given purpose or problem
- Understanding of the importance of data synthesis and able to implement the best methods for data integration
- Experience with digital twins, data visualisation and Artificial Intelligence desirable.

To discuss the role in more detail please contact Tim Smyth, tjsm@pml.ac.uk

For more information on PML visit www.pml.ac.uk
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Worst days in the world

The extinction event that wiped out the dinosaurs and forged a radically different future for Earth is captured in a must-read, says **Simon Ings**

Book

The Last Days of the Dinosaurs: An asteroid, extinction, and the beginning of our world
Riley Black

St Martin's Press

WELCOME to Hell Creek, in what is now Montana. But readers better not get too attached to the inhabitants dreamed into being in the first chapter of a vivid new book, *The Last Days of the Dinosaurs* by Riley Black, a palaeontologist and prolific writer.

We meet the *Tyrannosaurus rex*, "her reddish brown hide now draped in orange and gold from the low-angled light of the evening sun", the low-slung herbivore *Ankylosaurus*, defending herself with a car-tyre-sized tail club, and the *Alamosaurus sanjuanensis* hatchling that will never get to grow into one of the largest animals ever to walk the earth.

An asteroid impact killed dinosaurs over days and months

UGURHAN/GETTY IMAGES

Tomorrow, a 10-kilometre-wide asteroid, later to be known as the Chicxulub impactor, will plough into the ancient Yucatán in what is now Mexico. It will trigger the extinction of about three-quarters of all the species on Earth.

Along with all non-avian dinosaurs, the great bat-winged pterosaurs will perish. *Quetzalcoatlus*, with a wingspan wider than a Cessna plane, will disappear. Later, invertebrates such as ammonites will stutter and stop in seas made corrosive by acid rain. Most early mammals – those that didn't go up in flames or get blasted off into space – will eventually starve, and with them, most lizards, snakes and birds.

Subsequent chapters offer more glimpses of the aftermath, each separated by an exponentially longer interval.

An hour after impact and in Hell Creek, more than 4500 kilometres from the impact, a puzzled *Ankylosaurus* fights for its footing at the edge of a lake. Safe in her burrow, a squirrel-like *Mesodma* sleeps through a day of pulsing, planetary conflagration.

A month in, and little two-toed *Acheroraptors* are poking about in the decaying debris, unaware of the cold and hunger to come.

Time accelerates. A year, a hundred years, a thousand years go by. We venture far from Hell Creek, and learn much about dinosaurs and their long history, about the mechanisms of evolution and climate, and about the deep history of our planet.

We learn to abandon old notions of a planet healing itself, or of life returning to some ideal degree of diversity. Mass extinctions are, we discover, not "opportunities", and when living designs are lost in the great game of adaptation and extinction, they stay lost. Life got through by the skin of its teeth.

"It is as if Black had set up camp in the very heart of the valley that best captures the catastrophe"

Hell Creek remains central throughout, as is only reasonable because its geology appears to record in such extraordinary detail the events immediately following the Chicxulub impact. We glimpse it as an Eden, gardened by towering herbivores. We see it go up in flames. We say goodbye to the place as new plants smother and entangle it, creating the jungle environments from which complex behaviours and communities – primate and avian – will be born.

Throughout, Black's shifting cast of characters remains vivid and charming. Indeed, it is as if she had set up camp in the very heart of the valley that best captures the catastrophe and its aftermath. This is palaeontology written with the immediacy of natural history.

In a long appendix, Black explains what is real in this book, and what she has made up. But there is no need to worry: without a leavening of intelligent speculation, palaeontologists have never been able to say too much.

It is a point that Black makes splendidly, with reference to an illustrated book from 1863, *The World Before the Deluge*. This was published just a couple of years after the discovery of the first decent fossilised skeleton of *Archaeopteryx* – a previously missing link between reptiles and birds. The only problem was that the head was missing.

"Did *Archaeopteryx* have a beak? Teeth? Both? Neither? There was no way to answer the question," writes Black. "And so *The World Before the Deluge* portrayed *Archaeopteryx* flying high above Jurassic conifers totally headless."

Black's approach is much more sensible, adding whatever she needs – a head here, a behaviour there – to give us more-or-less reliable glimpses into the period after the worst day ever suffered by life on Earth. ▮

Hanging on in there

A nail-biting documentary about a trek to climb a remote mountain has an unexpected star, finds **Gregory Wakeman**

Film

Explorer: The Last Tepui

Renan Ozturk, Drew Pulley, Taylor Rees

Disney+

NATIONAL GEOGRAPHIC/RENAN OZTURK

Federico Pisani, part of the documentary team, on the cliff face of Weiassipu in Guyana

THOSE of you who have seen the astounding National Geographic documentary *Free Solo* will know just how mesmerising it can be to watch a professional climber scale the side of a mountain.

A new documentary, *Explorer: The Last Tepui*, shares a lot with *Free Solo*, which won the 2019 Academy Award for Best Documentary Feature. Not only does it also star rock climber Alex Honnold, it shows him dangling off the side of a mountain in precarious positions that will make your stomach drop in terror.

While his athletic feats are astounding, Honnold isn't the most captivating character in the film. That honour goes to Bruce Means, who has spent his academic career finding and cataloguing new species throughout South America to prove to the world and its governments that the area is a biodiversity hotspot to be protected at all costs.

In *Explorer: The Last Tepui*, the 80-year-old ecologist and conservationist is intent on climbing the 300-plus metres to the peak of a remote table-top mountain, or tepui, deep in Guyana's Amazon rainforest.

Means, Honnold, expedition leader Mark Synnott and a world-class team of climbers have to hike 56 kilometres over 10 days across increasingly treacherous terrain to reach the base of the tepui. This is a very big deal because Means has problems just bending his knees.

Once at the tepui, team members plan to climb to the top and then pull Means up, which will allow him to explore the cliff wall for novel animal and plant species.

Directors Taylor Rees, Renan Ozturk and Drew Pulley do a superb job of setting up the aim of the expedition, as well as the myriad difficulties that could blight it. Fully aware of the extraordinary visuals and fascinating characters that they have at their disposal, they take a step back and allow the majesty of the rainforest to take over, while giving the highly intelligent and passionate specialists room to describe what makes it so special.

Some of the shots that Matthew Irving, director of photography, captures are awe-inspiring, and the directors also provide plenty of long, lingering views of mountains, creatures, streams and waterfalls, which allow viewers to soak up the natural beauty, listen to the sounds of the animals and get lost in the frame.

What makes the documentary so riveting is Means's detailed explanations as he walks with the team through the forest, which is dense with trees and vegetation. The ecologist's positive and self-deprecating nature makes him instantly likeable, while his endless knowledge and devotion to nature and science are so contagious that they will make viewers of all ages appreciate the diversity of our environment.

His efforts are made all the more valiant by his admission that if he makes it to the summit, it will be the culmination of his life's work. Unsurprisingly, because of the unforgiving terrain they must cross to reach the tepui, various major obstacles soon get in the way of the party. Means's strain at holding up the expedition because of his age and health doesn't just make him more lovable, it injects real suspense into the documentary, which will debut on Disney+ on 22 April for Earth Day.

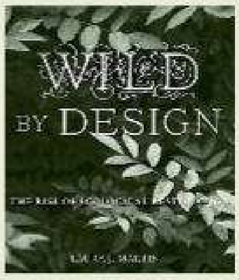
The constantly changing viewpoints and potentially life-threatening issues ensure that *Explorer: The Last Tepui* remains compelling to the very last frame. Even though it is just 54 minutes long, you will still feel utterly exhausted, as well as inspired, by the time it is over. ▮

Gregory Wakeman is a film writer and journalist based in Philadelphia

Don't miss

Watch

The Velvet Queen herself – the snow leopard – comes to selected UK and Irish cinemas on 29 April, accompanied by wolves, bears, yaks, birds and the fabulous and untouched landscapes of the Tibetan plateau.



Read

Wild by Design by environmental historian Laura Martin examines how we ended up casting ourselves as the "managers" of wild spaces, and goes on to ask whether we can design natural places without destroying wildness.

Watch

The philosophy and science of the disrupted mind are explored by philosopher Noga Arikha (pictured) and neuroscientist Katerina Fotopoulou in this online talk by The Royal Institution at 7pm BST on 26 April.

VINCENT MUNIER; JOSHUA VAN PRAAG/ROYAL INSTITUTION

Currents in time

The new novel from *Station Eleven*'s author is a fascinating tale of time travel – with disturbing glimpses of our pandemic-strewn future, says **Clare Wilson**

Book
Sea of Tranquility
Emily St John Mandel

Picador

IT SAYS a lot about Emily St John Mandel's imagination that while there are multiple instances of time travel in her new book, *Sea of Tranquility*, this is only one of several intriguing plot strands.

The novel, Mandel's sixth, is a welcome return to science fiction after her contemporary outing, *The Glass Hotel*. Her highly successful fourth novel, *Station Eleven*, is set 20 years after a deadly pandemic, and although Mandel has said that she didn't see that book as sci-fi, she now seems to be embracing the genre. Most of *Sea of Tranquility* is set centuries into the future, when people have colonised the moon and even the nearby star systems.

Stories that feature time travel usually have to wrestle with its potential paradoxes somehow. Even if a time traveller doesn't murder their grandfather, thereby preventing their own birth, they have changed the past simply by being there, which could have knock-on effects on the present day. So, which version of reality is correct: the one where the time travel happened, or the one where it didn't? And does this mean time travel is impossible?

One of the neatest literary solutions I have seen so far comes from William Gibson in his novel *The Peripheral*. This holds that travelling to the past is possible, but whenever it happens, the universe branches off into a separate timeline, so there are now multiple versions of reality.

Mandel has a different, mind-bending approach, although it would be an awful spoiler to reveal too much. Suffice to say that in her universe, time travel isn't all fun and games – in contrast to the expectations of her character Gaspery-Jacques Roberts, an apparently shiftless hotel security guard on the moon whose physicist sister Zoey lands him a job as a time anomaly investigator.

SHUTTERSTOCK/TOMERTU

Time travel isn't all fun and games in *Sea of Tranquility*

In this world, the moon-based Time Institute keeps time travel tightly regulated. People can only visit the past to carry out scientific investigations and must undergo years of rigorous training and research so they blend in.

This can make the experience traumatising. "You step into a party, and you know exactly how and when each and every person in that room is going to die," says Zoey, who works for the Time Institute. "You might be talking to a woman, let's say she has young children. The one thing you absolutely cannot say to her is 'Don't go swimming next week'."

Station Eleven, centred on a flu pandemic, enjoyed a surge of popularity thanks to covid-19. It has also been turned into an HBO Max TV series. In *Sea of Tranquility*, by the time we are living on the moon, there have been many pandemics, caused by coronaviruses, influenza and Ebola.

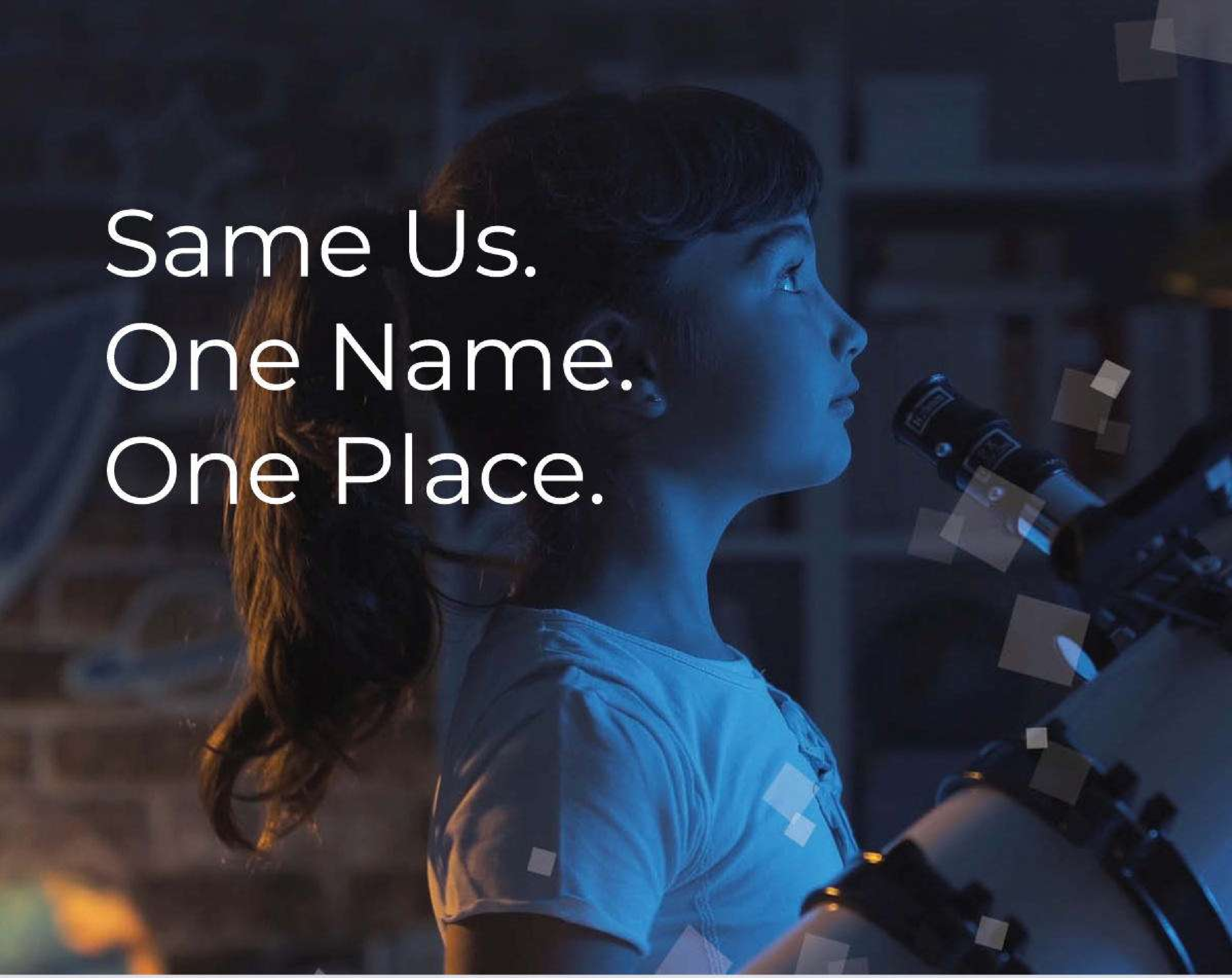
> "In this world, people can only visit the past after years of rigorous training and research so they blend in"

It is good to see that, in this universe at least, none of these outbreaks were civilisation-ending, but it is jarring to see the people of 2401 casually referring to "SARS Twelve".

And when we zoom in on one woman's experience of fleeing a particularly deadly pandemic in 2203, Mandel convincingly describes her gut-clenching terror.

Armed with unique foreknowledge of how bad things will get, the fleeing woman, Olive Llewellyn, upends her life to catch one of the last flights from an infested Earth. She frantically tries to convince a sceptical husband by phone to take what may be life-saving precautions, such as pulling their child out of school and accepting the need for stockpiling food. In light of covid-19, many readers will empathise with that rising tide of panic.

If I have one complaint about *Sea of Tranquility*, it is that some of Mandel's fascinating ideas about time and physics are mentioned too briefly without being fully explained. The book is relatively short and it left me wanting more. I hope these are topics that the author will explore in her next work. ▮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THE BLUE ACCELERATION

Humanity's expansionist drive is increasingly taking us into the deep ocean. How can we balance that with vital environmental protections, asks **Graham Lawton**

IN THE 1970s, the tiny Pacific island state of Nauru was briefly one of the richest countries in the world. Its per-capita income was on a par with Saudi Arabia, only this wealth was built not on oil, but on faeces. For millennia, passing seabirds deposited their droppings on the island, creating a thick crust of phosphate-rich guano, ripe to be made into fertiliser.

It didn't last: the guano was all scraped away around 20 years ago. Now Nauru, no longer filthy rich, is the prime mover in another, controversial push to exploit resources. As of last year, the country is fronting an effort to kick-start deep-sea mining in the Pacific, perhaps as early as 2023.

It is a microcosm of a much wider story. As pressures on Earth's land grow and terrestrial resources look increasingly exhausted, governments and corporations are seeing the next big wins on, in and under the high seas. Whether it is mineral exploration, shipping, energy, tourism, desalination, cable laying, bioprospecting or more, ocean-based industries are picking up speed fast.

This "blue acceleration" has many people worried. Our record on sustainable development on land is hardly good. With the power to profit from remote ocean resources growing rapidly, and the laws that govern their exploitation less than clear, we risk a free-for-all in the deep. "Our society has been based on the degradation of nature, destruction of nature," says marine ecologist Enric Sala, a National Geographic Explorer in Residence. "It is very important to understand that we cannot repeat the mistakes of the land in the ocean." The multibillion-dollar question is: how?

Exploiting – indeed, overexploiting – the oceans isn't a new story. Think of the collapse of whale populations through hunting in the 19th and 20th centuries, the loss of once-plentiful fisheries and the destruction of the seabed by bottom trawling. But in the past decade or so, our interest in the oceans has taken on entirely new dimensions. In 2016, the OECD, a club of rich-world countries, forecast that the marine economy would become a key driver of global economic growth, doubling in size to around $3 trillion between 2010 and 2030.

"We are in a new phase of humanity's relationship with the ocean," says Jean-Baptiste Jouffray at the Stockholm Resilience Centre at Stockholm University in Sweden. "You have all these hopes and expectations for the ocean to be the next economic frontier and the engine of future human development." Jouffray and his colleagues coined the term blue acceleration in a paper they published in 2020. It riffs off the Great Acceleration, the name given to the period starting in about 1950 when every measure of humanity's impact ›

NARVIKK/GETTY IMAGES

> "THE OCEANS ARE EXPECTED TO BE THE ENGINE OF FUTURE HUMAN DEVELOPMENT"

Container shipping now carries 80 per cent of global trade by volume

WHAT MAKES THE OCEANS DIFFERENT?

Switching to more sustainable development on land is hard enough, but the OECD report *The Ocean Economy in 2030* sets out nine things that make this even more difficult in the marine environment.

1. The sea is much larger than the land surface, subject to different legal regimes and with natural processes, species and ecosystems that cross between them.

2. Water is less transparent than air, making remote sensing of the oceans and the seabed more difficult.

3. The sea is more three-dimensional, adding to the complexity of mapping, planning and managing processes and activities within it.

4. It is fluid and interconnected, allowing for easier transport of pollutants and alien species.

5. Marine species travel further, making the management and tracking of resources more difficult.

6. Marine species can shift location rapidly, so measures to protect them in one place may be less effective as time goes by.

7. Nutrients and pollutants can cycle in the ocean for decades, making it harder to assess the long-term impact of human activities.

8. There is a lack of ownership and responsibility in much of the ocean, making regulation and exclusion of non-authorised activities harder.

9. Humans don't live in the ocean, requiring the development of new technologies for its exploitation and making law enforcement more difficult and costly.

MIGUEL NAVARRO/GETTY IMAGES

Wind power could require 45,000 km² of European waters by 2050

on the planet's land surfaces, from population growth to resource extraction, grew rapidly.

The new plunge into the ocean has come about in part because technologies – from ocean drilling and offshore wind turbines to desalination plants and factory trawlers – have made it possible. "A lot of offshore industries were unthinkable even just a few decades ago," says Jouffray.

And sustainable isn't exactly a word you would use for the bulk of today's marine industries. By far the largest sector of today's $1.7 trillion ocean economy is offshore production of climate-polluting oil and gas, which rakes in $830 billion a year, followed by the construction of marine equipment, fisheries and container shipping – the last a major, largely unregulated emitter of greenhouse gases. In this list, sustainable industries of the future barely register. Offshore wind trails in a distant 8th, with revenues of just $37 billion (see "Blue business: Power and comms", right).

That state of affairs is taking a toll. "The ocean is already in a deep crisis," says Sebastian Unger at the Institute for Advanced Sustainability Studies in Potsdam, Germany. More than 50 per cent of it is already impacted by biodiversity loss, noise from human activity, chemical influx and plastic pollution, he says, and few parts are completely untouched. Meanwhile, a target for 10 per cent of coastal and marine areas to be protected by 2020, especially those of particular importance for biodiversity, was missed, with 7.7 per cent protected in some way, only 2.7 per cent completely protected – and just 1 per cent of the high seas.

Visions of a more sustainable future have been swirling around since the 2010s, sometimes under the guise of the "blue economy" – although not everyone is a fan of that term, which can also be used to mean continued unsustainable exploitation. "That's not what we want to see," says Julian Barbière at UNESCO's Intergovernmental Oceanographic Commission. "We need to find the right balance between conservation and economic development."

Many factors currently militate against that. For a start, the current ocean economy is heavily concentrated in the hands of a small number of established companies. Nine of the 10 biggest are oil firms. Research led by John Virdin at Duke University in North Carolina found that in the eight largest sectors of the ocean economy – the five already mentioned, plus shipbuilding, cruise tourism and ports – just 100 companies hog 60 per cent of the revenues. They are largely headquartered in just six countries: the US, Saudi Arabia, China, Norway, France and the UK. "It's the usual suspects," says Jouffray.

And the status quo pays handsomely. Around 40 per cent of offshore oil and gas revenues, for example, end up in government coffers, and governments respond in kind

BLUE BUSINESS: POWER AND COMMS

The world's first offshore wind farm opened off the coast of Lolland, Denmark, in 1991. Since then, the global installed capacity has grown to nearly 35 gigawatts – enough to power the entire UK – almost all of it in European (25 GW) and Chinese (9 GW) waters. Other sources of ocean renewable energy are also being eyed up, including waves, tides, currents, salinity gradients, thermal gradients and marine biomass. The EU has a target of installing 1 GW of these alternative sources by 2030, says Benjamin Lehner at the Dutch Marine Energy Centre in The Hague.

All these figures are a drop in the ocean compared with the world's 1840 GW of gas-fired power capacity. Yet with wind power generation getting cheaper all the time – costs declined 70 per cent between 2012 and 2021 – rapid growth looks like a foregone conclusion. The trade association Wind Europe estimates that, by 2050, Europe will have 450 GW of offshore wind.

That brings its own challenges. It will require about 45,000 square kilometres of ocean, most of it between 11 and 22 kilometres from shore, the goldilocks zone for offshore wind. Europe has 550,000 square kilometres of this real estate in total, but more than 60 per cent is earmarked for marine protected areas, says António Sarmento at consultancy firm WavEC Offshore Renewables in Lisbon, Portugal. Building, operating and maintaining offshore wind farms can damage the seabed, while the power cables that carry electricity to shore emit electromagnetic fields to which some species are sensitive.

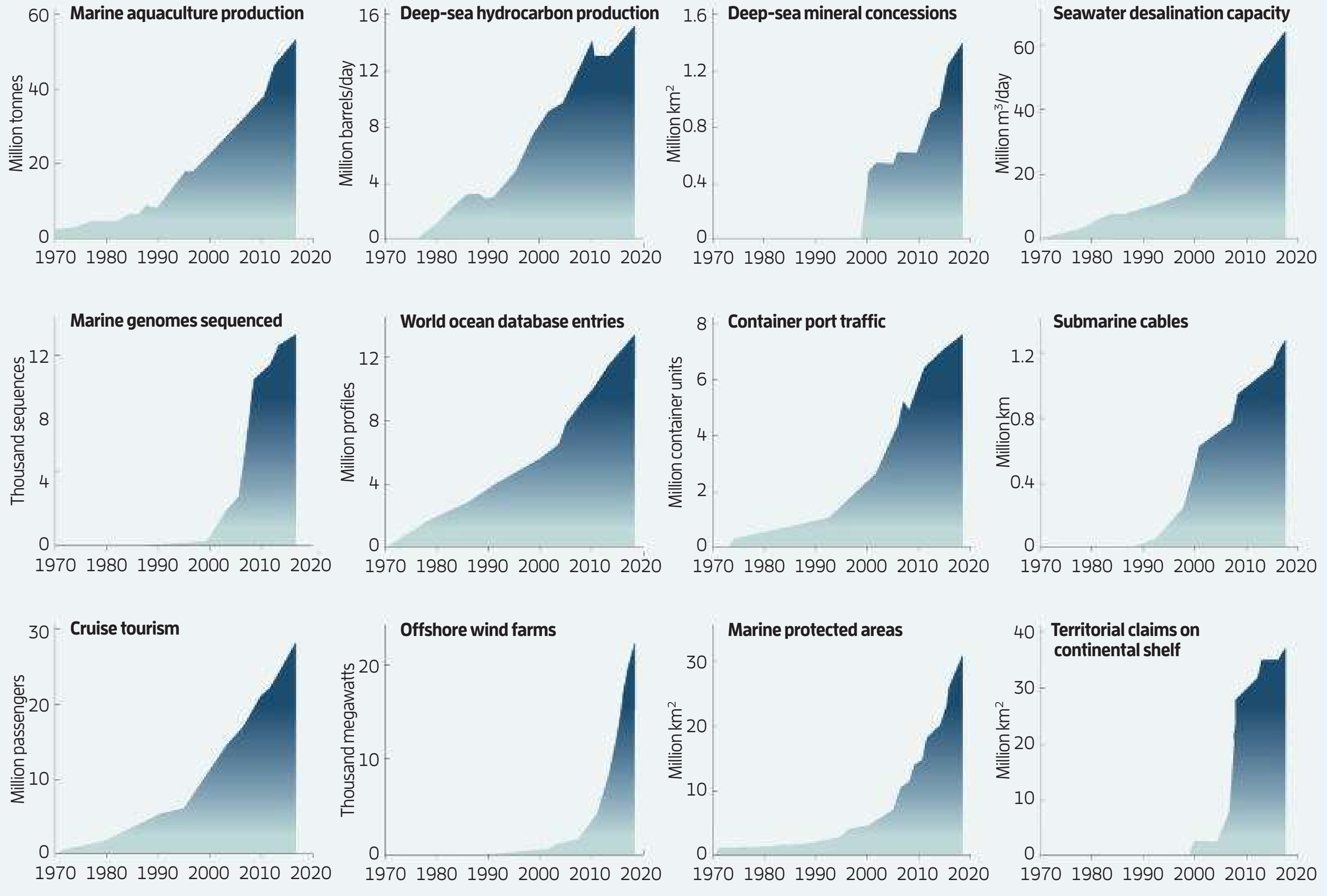
A possible answer, says Sarmento, is the "multi-use of maritime space" – combining wind farms with marine protected areas and adding in seaweed and shellfish farming. "We can create economic value, we can create local jobs and we can do something in benefit of the environment," he says.

Meanwhile, around 99 per cent of international telecommunications is carried by undersea fibre-optic cables. The current network, known as the "cloud beneath the sea", stretches for 1.4 million kilometres and is lengthening constantly as demand for bandwidth grows.

Cables are either buried in the sediment or simply laid on the sea floor. Both have a minimal ecological footprint, says Lionel Carter at Victoria University of Wellington, New Zealand, who was marine environmental adviser for the International Cable Protection Committee from 2003 to 2019. In fact, cables can have a positive effect on the environment, as critical infrastructure for sustainable development in lower-income parts of the world and a barrier to destructive trawling of the seabed for fish. The very first marine cable, a telegraph line laid between Dover and Calais in 1850, was caught and cut by French fishermen who mistook it for seaweed.

RACE TO THE BOTTOM

Most measures of human activity in the ocean have increased significantly in the past half-century



SOURCE: JOUFFRAY EL AL. DOI.ORG/GG4RDF

> “WE CAN CREATE ECONOMIC VALUE AND JOBS AND PROTECT THE OCEAN ENVIRONMENT”

BLUE BUSINESS: DEEP-SEA MINING

Minerals companies have been coveting the deep seabed since the 1960s. According to one industry analysis, deep-sea mining could grow from essentially zero today into a $15-billion industry by 2030.

The International Seabed Authority, established in 1994 to regulate the industry's development, has handed out 31 exploration licences to 21 contractors so far. But it can't yet authorise commercial deep-sea mining operations as its member states are still thrashing out the rules.

That could be about to change. In June 2021, the Pacific island state of Nauru triggered a clause of the UN Convention on the Law of the Sea demanding that the rules be finalised within two years. It is acting as a state sponsor for a private firm, The Metals Company, based in Vancouver, Canada, that wants to develop a mine not near Nauru, but at the eastern end of the Clarion-Clipperton Zone (CCZ), on the other side of the Pacific Ocean roughly between Hawaii and Mexico.

The CCZ is thick with potato-sized metallic nodules rich in nickel, cobalt, copper and manganese, all critical metals for the green energy transition. The nodules lie on the seabed and The Metals Company describes its planned operation as "collection" rather than mining. It and other proponents of deep-sea mining claim this approach is environmentally more benign than mining on land. The CCZ is mostly abyssal plain, the most common type of environment on Earth, covering about a third of the ocean floor. "It is pitch black, cold, high pressure and food-poor, resulting in 1500 times less biomass than in a rainforest," says Rory Usher at The Metals Company. "It is essentially a desert."

Others disagree. "There is remarkable diversity in these areas," says Megan Cook at the Ocean Exploration Trust. "We find many species here that rely on the nodules, using that hard platform of a nodule to grow off, like sponges and anemones, and we're still encountering dozens of new species each time an expedition goes there." The denser the nodules in an area, the richer the biodiversity, she says.

Two other sources of deep-sea metal ores have mining companies salivating: sulphides found around hydrothermal vents, and cobalt crusts covering flat-topped seamounts called guyots. Exploiting both is much more destructive than plucking loose nodules off the abyssal plain.

Nautilus Minerals, a Canadian company in which the government of Papua New Guinea held a stake, attempted to mine hydrothermal vents in the territorial waters of Papua New Guinea, starting in 2011. The venture collapsed in 2019. For now, the CCZ is the only part of the deep seabed outside national territorial waters in play for mining as it is the only area for which the International Seabed Authority has completed a mandatory piece of paperwork called a regional environmental management plan.

But Nauru may also have accessible minerals inside its own waters, which could be exploited once a deep-sea mining industry is established in the CCZ. Other island nations have signalled their intent to go down that road: the Cook Islands, for example, has nodules galore and plans to exploit them as soon as it can, even though its waters are designated as a marine protected zone. Such plans within territorial waters are beyond the reach of the International Seabed Authority. Around 900,000 square kilometres of seabed under national jurisdiction are under exploration for mining.

Many species that inhabit the deep sea, such as this glowing sucker octopus, remain under-researched

CAROLYN COLE/LOS ANGELES TIMES VIA GETTY IMAGES

Researchers disembark a ship in San Diego, California, from the Clarion-Clipperton Zone with lucrative subsidies. Over the past 10 years, less than 1 per cent of the total value of the ocean economy has been invested in sustainable projects via philanthropic grants and government assistance, says Jouffray. Redirecting subsidies that currently prop up overfishing and offshore fossil fuel development has been on the to-do list of the World Trade Organization (WTO) for 20 years.

There are some vaguely positive signs. Finance for the ocean economy largely comes from the world's big asset managers – BlackRock, Vanguard, State Street and the like. They are gradually seeing the light on green investment onshore, says Jouffray, and there is some hope the same thinking might percolate into offshore investments.

But it isn't just finance. Another hindrance to sustainable development and ocean conservation is simply a lack of knowledge of what we are trying to develop and conserve (see "The unknown deep", left). Then there is the disjointed way different ocean activities are – or are not – overseen by various UN agencies: shipping by the International Maritime Organization, fisheries by the Food and Agriculture Organization (FAO), biodiversity by the UN Environment Programme, science by UNESCO, and so on. "These sectors don't speak to each other," says Unger.

Cutting across this is UNCLOS, the UN Convention on the Law of the Sea, which came into force in 1994. This established "exclusive economic zones", or EEZs – areas of the sea out to 200 nautical miles (370 kilometres) from a country's shore over which it has full sovereignty and exploitation rights, provided there is no overlap with another country's EEZ. It also enshrined the relative lawlessness of what lies outside these zones. Technically called the Area Beyond National Jurisdiction, this is subdivided into "the Area", denoting the seabed and what lies beneath it, and "the High Seas", for the water column above it. The UN says resources in these places are the "common heritage of all mankind", while obliging every country to protect and preserve the marine environment.

"UNCLOS was an amazing, extraordinary achievement of international cooperation, but it leaves two-thirds of the ocean beyond jurisdiction," says Virdin. "At least, two-thirds of everything above the seabed." The Area is governed by the International Seabed Authority, established as part of UNCLOS to regulate future mining there – an issue that now, thanks to Nauru's move, has become very live (see "Blue business: Deep-sea mining", far left).

This gappy regulatory system has been left floundering in the wake of the ›

> **"ONE HINDRANCE TO OCEAN CONSERVATION IS NOT KNOWING WHAT WE ARE CONSERVING"**

DAVID SHALE/NATUREPL.COM

THE UNKNOWN DEEP

The oft-quoted factoid that more people have walked on the moon than have visited the deepest part of the ocean, the Challenger Deep in the Pacific Ocean, is no longer true – the score stands at moon 12, ocean 22. But we still know little about the deep ocean, especially its remoter parts. "We only have about 20 per cent of the ocean sea floor mapped in high resolution. We only have systematic observation on the top 2000 metres, we have very little observation in the deeper parts," says Julian Barbière at UNESCO, the UN body that takes the lead on ocean science.

A complete map would be a big boost to ocean science, and is also essential for a more sustainable ocean economy. "You wouldn't build a city on an area that you haven't mapped; you wouldn't build a house in a field that you haven't mapped," says hydrographer Jamie McMichael-Phillips. "But we are operating in our oceans and using ocean resources when we haven't mapped our oceans."

"You need a map to figure out what you're going to do with these things," says Catherine Novelli, former under-secretary for economic growth, energy and the environment at the US Department of State. "Not only how are you going to conserve them, but how are you going to economically make use of the resources that are there. If we want to preserve the ocean so that it can be a sustainable resource, we have to have a map."

McMichael-Phillips is director of the Nippon Foundation-GEBCO Seabed 2030 Project. GEBCO stands for General Bathymetric Chart of the Oceans, a mapping project set up in 1903 by Prince Albert I of Monaco. It started life as a hand-drawn contour map created by dropping lead-weighted lines onto the seabed, but has since evolved into a high-resolution digital chart of sonar readings.

But sonar is slow and only 20 per cent of the chart is drawn. Seabed 2030 intends to capture the remaining 80 per cent in just over eight years, which McMichael-Phillips accepts is a "monumental task" – but a doable one. "We've calculated that it's 200 ship years: one ship operating for 200 years to map the ocean floor," he says. "You can drive that down to 50 ships in the remaining eight years. And that makes our mission entirely achievable."

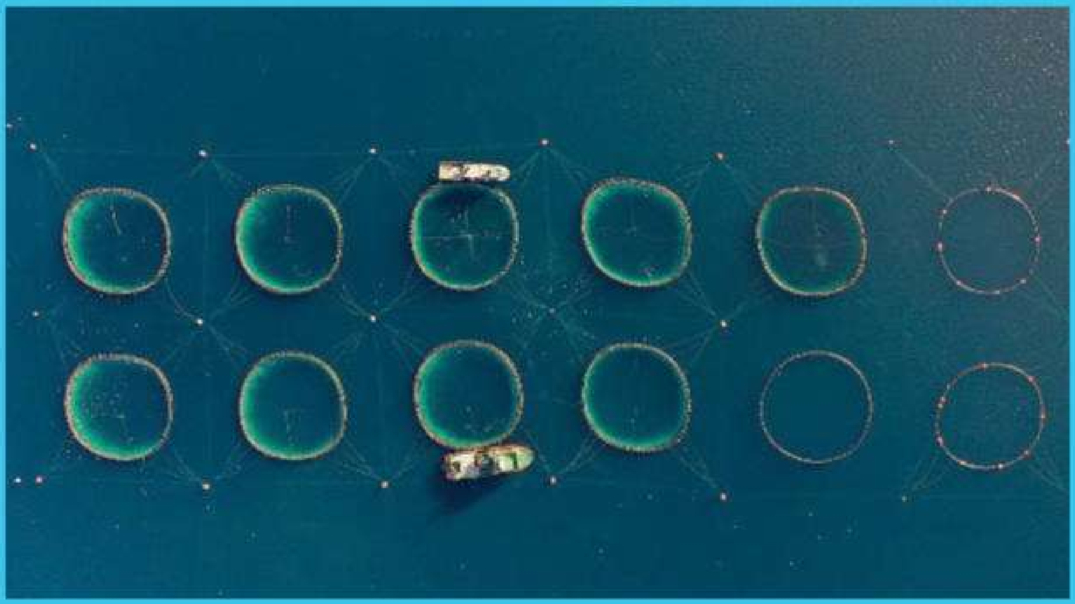
blue acceleration. As recognition of the potential riches in EEZs has increased, nations' attempts to claim more of the sea as their own have too (see "Ocean grabbing", opposite page). Meanwhile, technology is making it easier to exploit parts of the high seas. The system as it stands makes sustainable development of the ocean all-but impossible, says Unger. "We need to transform how we are governing the ocean," he says.

In some places, this is happening, on paper at least. One example is the fishing industry. While UNCLOS guarantees access to the high seas, they are now far from the fishing wild west they once were, says Manuel Barange at the FAO. It helps that there aren't plenty of fish in the high seas. Nutrient availability means fish tend to be associated with a specific habitat, such as a sea bottom, a coral reef or a coastline. "In the middle of the ocean, you have tuna and marlin, but you don't have much more," says Barange. Large areas where fish actually live are now governed by a patchwork of some 50 agreements between countries known as Regional Fisheries Management Organisations (RFMOs) – something that should be extended to all international waters, says Barange.

Regulated the right way, there is no reason why our demand for seafood can't be supplied sustainably (see "Blue business: Aquaculture", right). The same goes for other aspects of the oceans. One effort to do this is the proposed UN-sponsored BBNJ treaty, for Biodiversity Beyond National Jurisdiction. Its principal goals are to lay down rules for the creation and protection of marine reserves, the requirement for environmental impact assessments of planned economic expansion into the high ›

> "TWO-THIRDS OF THE OCEANS ARE CURRENTLY HARDLY REGULATED"

BLUE BUSINESS: AQUACULTURE


MAHMUT SERDAR ALAKUS/ANADOLU AGENCY VIA GETTY IMAGES

Humans eat seafood in copious quantity and variety. Annual global consumption is around 155 million tonnes, about a third of all of the animal flesh eaten in total, with demand forecast to double by 2050. More than 2000 species are consumed worldwide.

Even now, that has a devastating effect. Around 70 per cent of wild fish stocks are overfished, says Julian Barbière at UNESCO, while fishing methods such as bottom trawling are horribly destructive. Modern fishing vessels burn a lot of oil to chug around the ocean, haul their nets and refrigerate their catch, making the average carbon footprint of a kilogram of wild-caught fish greater than that of a kilogram of pork and approaching that of beef.

Overfishing meant hauls from wild-caught fisheries plateaued in the 1990s. Most growth in consumption since then has been supplied by farming, or aquaculture, which now provides half of the seafood eaten worldwide. It is no panacea, however. The Aichi targets on biodiversity, which were set in 2010 and expired in 2020, called for aquaculture to be "managed sustainably, ensuring conservation of biodiversity". Along with all the other targets, it was missed by a nautical mile. Among the charges against aquaculture are destruction of coastal wetlands, especially mangroves, huge energy cost and the inefficiencies of a system that relies on feeding small fry such as anchovies to larger fish.

The notion that aquaculture as currently practised can feed the world is nonsense, says Daniel Pauly at the University of British Columbia in Canada. "Actually, it can feed the rich. It takes fish that were available to poor people and turns them into fish that are preferred by rich people. It's as crude as that," he says.

In 2021, Jessica Gephart at the American University in Washington DC and her colleagues took a deep dive into what they call "blue food", a catch-all category for anything edible from fresh water or the sea. That includes fish, shellfish and cephalopods, but also an aquarium of lesser-eaten creatures such as sea cucumbers, jellyfish, seaweed and microalgae. If managed carefully, they concluded, blue foods have a lot of room for sustainable growth. "There is such a thing as sustainably managed fisheries," says John Virdin at Duke University in North Carolina. "It takes smart rules and enforcing those rules, but it can be done. And it's not impossible to do aquaculture sustainably."

Part of that is eating more seaweed and bivalves such as oysters and mussels, which have a minimal environmental impact and can be powerful carbon sinks. It may mean more salmon, which can thrive on a vegan diet and have a footprint comparable to rearing chickens, the most efficient form of land-based meat. Sea urchins also look promising. Farmed bluefin tuna isn't the answer, but wild-caught tuna may be, provided the fishing industry switches to less energy-intensive trawlers and fishing gear.

OCEAN GRABBING

Nauru is the smallest island nation on Earth, with a land area of 21 square kilometres, little bigger than the London Borough of Hackney. If you count its exclusive economic zone (EEZ), stretching up to 200 nautical miles out to sea in each direction, however, that increases to 308,480 square kilometres, around 15,000 times bigger than the island itself and roughly the size of Poland. Other island nations command even vaster areas by virtue of being scattered archipelagos. Nauru's neighbour Kiribati, which is composed of 33 atolls and islands strung across 3.5 million square kilometres of the equatorial Pacific, is the 172nd largest nation on Earth by land area, but the 12th by EEZ.

These island nations are increasingly rebranding themselves. "We may be small island developing states, but we are also large ocean developing states. We are a lot bigger than we think we are," Camillo Gonsalves, minister of finance of St Vincent and the Grenadines, told a meeting of the Organisation of Eastern Caribbean States in 2020. "We must cast our eyes outward and recognise that the beach or the coastline is not the edge of our world, but the beginning of the immense untapped resource that can sustainably fuel our growth and development."

The realisation that surrounding seas may harbour vast untapped wealth has added another dimension to the "blue acceleration" (see main story), called ocean grabbing. This is where a country attempts to extend its marine territory by claiming dots of land or discovering hitherto-unknown bits of continental shelf: under the UN Convention on the Law of the Sea, countries can claim areas of continental shelf as their own even if they lie beyond 200 nautical miles from the shore.

Russia set the ball rolling in 2001 when it claimed 1.2 million square kilometres of the Arctic Ocean along an the undersea Lomonosov Ridge, which it says is an extension of Siberia. Denmark begs to differ, claiming that the feature it calls Lomonosovryggen is an extension of Greenland.

Since then, 83 other countries have submitted claims to the UN, totalling over 37 million square kilometres of sea floor. Some have succeeded. In 2012, Australia claimed and was later granted more than 2.5 million square kilometres of seabed around a remote cluster of uninhabited islets in the Southern Ocean. "It has literally been a scramble for the seabed," says Jean-Baptiste Jouffray at Stockholm University in Sweden.

THE METALS COMPANY

Top left: A tuna farm near Izmir, Turkey. Above right: The Nauru government is sponsoring Canada-based The Metals Company to harvest metal-containing nodules from the ocean floor

seas, and the fair and sustainable use of genetic resources, seen as important for the emerging ocean biotechnology industry (see "Blue business: Ocean bioprospecting", page 46). The completion of the BBNJ would be "an important step to create this new vision" of ocean governance for the two-thirds of it that is currently hardly regulated, says Unger. The negotiations have been dragging on for years, however, and the latest round of talks broke up in March without the hoped-for agreement.

Meanwhile, at the delayed Convention for Biological Diversity summit in Kunming, China, later this year, nations are due to agree a new set of biodiversity targets for 2030. Despite the comprehensive failure to meet the previous targets set in Aichi, Japan, in 2010 – including one for marine conservation areas – the 2030 draft agreement is significantly more ambitious, calling for at least 30 per cent of land, freshwater areas and oceans to be protected by the end of the decade (16 April, p 48). This "30 by 30" target would be a "game changer" for ocean conservation, according to Peter Thomson, the UN secretary-general's special envoy for the ocean.

There are reasons to be optimistic about the ocean part of the biodiversity goals this time round, says Sala. "We see countries understanding that there is no future to their ocean economies without protected areas." Fishing areas, for example, are much more productive and sustainable if they are next to zones where catching fish is banned.

More than 70 countries have pledged to hit 30 by 30 by joining the UK-led Global Ocean Alliance; more than 90 nations have joined the High Ambition Coalition for Nature and People, which is committed to 30 by 30 on land and sea. Last year, the UK created the 700,000-square-kilometre Tristan da Cunha Marine Protection Zone around this Atlantic

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archipelago and Costa Rica expanded the size of its Cocos Island National Park in the Pacific Ocean by 27 times. "We've seen this incredible increase, exponential increase, in the surface of the ocean that has been protected," says Sala.

There are other hopeful signs, too. The Glasgow Climate Pact, signed at the COP26 summit in November 2021, put ocean warming and acidification firmly on the to-do list, while the next round of climate talks, in Egypt this November, will continue the work of curbing what Thomson says is the "central nemesis of the ocean's problems" – greenhouse gas emissions. Even the shipping industry, a notorious laggard on this, is starting to think seriously about decarbonisation, with member states of the International Maritime Organization now committed to reducing shipping emissions by at least 40 per cent between 2008 and 2030 and reportedly tacking towards a commitment to hit net zero by 2050.

Meanwhile last month, the world agreed to negotiate a treaty to deal with plastic pollution. In June, the WTO will again attempt to abolish harmful fisheries subsidies, which currently fund industrialised plunder of fish stocks to the tune of $20 to $30 billion a year. Next up is the UN Ocean Conference in Lisbon, Portugal, in June and July, which will aim to set out the route to a science-based sustainable ocean economy with major participation from private companies and financiers.

But all of this is happening as the clock ticks. Virdin sees two possible trajectories between now and 2030, which is just a way station to 2050, a date the UN wants humanity to be living in harmony with nature again. One is business as usual, where we mindlessly trundle sideways like a crab. Another is much more positive, says Virdin. "Protection ramps up, maybe we hit 30 by 30. Shipping decarbonises, our emissions trajectory goes down. The WTO bans or reduces fishing subsidies. We develop standard reporting systems for the ecological and social footprint of the growing ocean economy. We get a treaty that sets meaningful targets to reduce the plastic waste. And then we start getting into ecological restoration, people see the merits in investing in that and it becomes a natural climate solution. That's a good scenario for 2030," he says.

Decisions we take this year will determine whether it is possible, and how far we move from the current situation to an ocean economy that is profitable, sustainable and equitable. "There are success stories, there are causes for optimism," says Virdin. "I am not a fatalist that it cannot be done, or that we shouldn't do everything we can to bend the curve."

It will still be a hell of a big ship to turn around. "We have major biodiversity loss, pollution and overfishing," says Barbière. "But if by 2030 we have sustainable ocean planning processes across all countries around the world, we will be in a much better shape than we are now. I think that is possible." ∎

BLUE BUSINESS: OCEAN BIOPROSPECTING

In 1951, bioprospectors from the drug company Pfizer isolated a compound from a species of sponge they had discovered off Florida and the Bahamas. Named spongouridine, it was later developed into an antiviral called vidarabine, the world's first-ever marine-derived drug.

Marine species are highly interesting to the biotech industry as they have evolved to live in extremes of pressure, temperature, chemistry and darkness not found on land, giving them potential biological superpowers likely to be useful in biomedicine and industrial applications. More than 34,000 natural products from the ocean have been identified as possibly useful to date, including one sponge-derived compound that was adapted to create the groundbreaking drug AZT, the first treatment for HIV infection. Since 1988, some 13,000 marine genetic sequences from 865 marine species have been patented. Around three-quarters are from microorganisms, but genes have also been extracted from fish, crustaceans, corals, molluscs, sponges and even whales.

As yet, this bounty has only yielded a handful of actual products, but advances in remotely operated vehicles and sampling technologies is expected to spur it on. By 2025, the global market for marine biotechnology is projected to reach $6.4 billion, according to Jean-Baptiste Jouffray at Stockholm University, Sweden.

SVEN ZEA/SPONGEGUIDE.ORG

The antiviral drug vidarabine was extracted from the sponge *Tectitethya crypta*

> **"DECISIONS WE TAKE THIS YEAR WILL DECIDE HOW SUSTAINABLE THE OCEAN'S FUTURE IS"**

Graham Lawton is a feature writer for *New Scientist*

Ghostbusting

What makes "ghosting", when someone ends a relationship by disappearing without explanation, so painful? **Amelia Tait** reports

IT WAS 2015 when Jennice Vilhauer's clients started telling her ghost stories. The Los Angeles-based psychotherapist had more than 10 years of experience helping people with their depression, anxiety and relationship issues – but suddenly, clients began telling her about a new problem, one that left them extremely distressed.

They were victims of ghosting, where one person ends all communication with another, disappearing like a phantom. Messages are ignored and just like that, the person you had a connection with – typically a romantic partner, but sometimes a friend or colleague – chooses to disengage with no explanation. But when Vilhauer searched for more information, she

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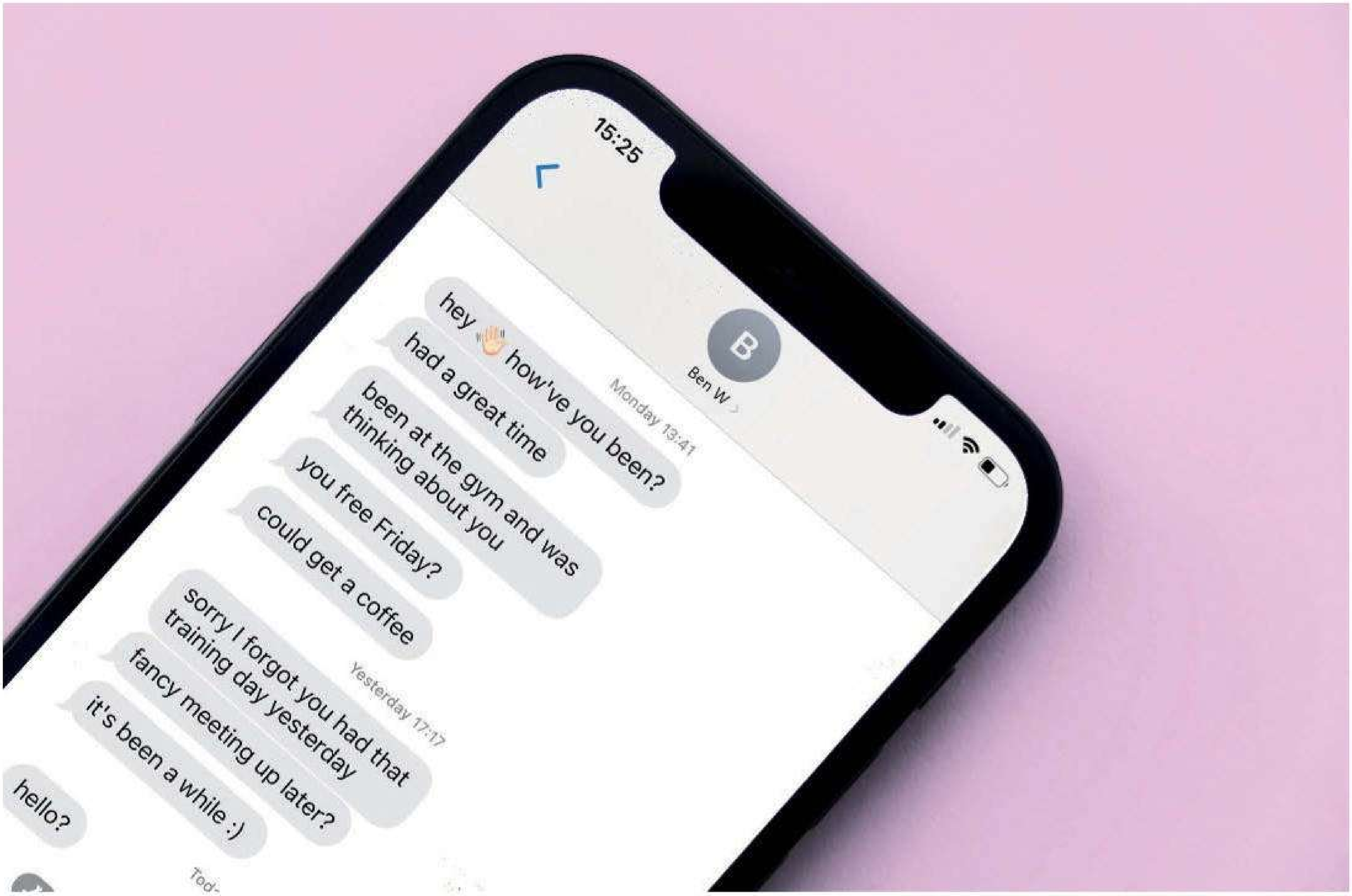


Monday 13:41

hey 👋 how've you been?

had a great time

been at the gym and was thinking about you

you free Friday?

could get a coffee

Yesterday 17:17

sorry I forgot you had that training day yesterday

fancy meeting up later?

it's been a while :)

hello?

Tod-

OFFWHITE

found little research on this phenomenon. So she started publishing her own observations online and was soon inundated with emails from people who had been ghosted. "There's been an enormous explosion of interest in this because it's happening so frequently," she says.

Which begs the question, what is uniquely painful about ghosting? After all, it nearly always hurts when a relationship ends. Is being ghosted any more distressing in the information age than, say, in the Wild West, when your lover hopped on their horse and left you in a trail of dust without so much as a forwarding address? We are now beginning to find out, as well as building a picture of why people ghost, how quirks of the brain can make it feel worse than it ought to and how, counter-intuitively, ghosting may be getting less painful.

Unexpected disappearance

Back in 2015, ghosting hurt so badly because it was completely unexpected, says Vilhauer – it wasn't something people mentally prepared for when entering a relationship. While disappearing from a relationship without notice has undoubtedly occurred throughout history, technology seems to have increased its frequency. One 2021 study by researchers at Wesleyan University in Connecticut noted that social media plays an "integral role in perpetuating ghosting" due to its anonymity and because it allows us to connect – and hence disconnect – with others easily. As one ghoster in the study said: "It's easier to hide behind the screen and not face the music."

Estimates of the prevalence of ghosting vary. One 2018 study of more than 700 US adults found that a quarter of them had experienced ghosting, but a 2016 survey of 800 people aged between 18 and 33 by the dating site Plenty of Fish put this figure at almost 80 per cent.

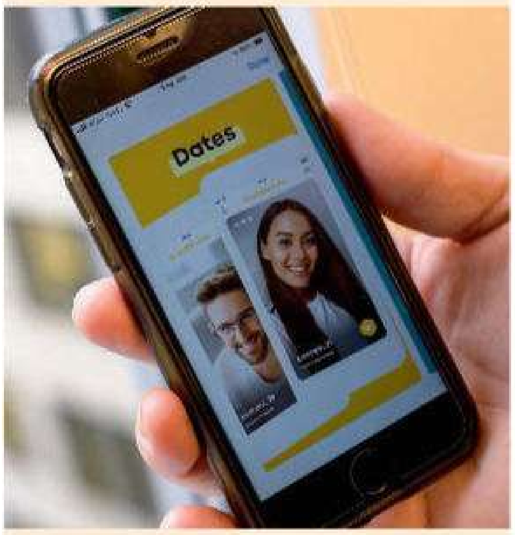
Vilhauer stresses that the pain of being ghosted is very real. It is a form of social rejection, which we know manifests similarly in the brain as physical pain – as illustrated in a 2011 study that gave new meaning to the idea that rejection hurts. This found that when people who had recently experienced an unwanted break-up were shown pictures of their ex-partner and asked to think about being rejected, the same brain regions that respond to physical pain were activated.

Yet this research isn't specific to ghosting, just rejection in general, and the few studies that have looked specifically at ghosting show conflicting results. A 2021 paper found that people who had experienced ghosting reported significantly higher levels of anxiety than those who hadn't. However, another study from 2019, of people who had experienced a break-up in the past five years, found no significant difference in the amount of distress experienced due these break-up methods. Interestingly, this study also found that the average length of relationship before ghosting was six months, illustrating that this practice isn't just employed to end a short-term, casual partnership.

While the amount of pain a ghosted person experiences might not be unique to this form of rejection, the psychological consequences can be. These effects are perhaps hard to understand if you haven't experienced them first-hand. When I tell a friend that I am writing about ghosting and mention that (as someone this has never happened to) I don't think it is "that bad", she quickly corrects me. She describes the experience as dehumanising and says her mind went into overdrive imagining horrible reasons why she was ghosted: "They found me repulsive, they were embarrassed to be seen with me." This friend estimates that she has been on around 70 dates with strangers from dating apps. She has no real memory of the people who told her directly they didn't want to see her again, "but I can remember each time someone ghosted very clearly", she says.

"My mind went into overdrive imagining horrible reasons why I'd been ghosted"

Scaring off ghosts



ERIC BARADAT/AFP VIA GETTY IMAGES

Ghosting may be an inevitable downside of today's digital dating scene, but some apps are fighting back. This year, the dating app Snack, aimed at the younger, TikTok-using generation, introduced features to deter ghosting. Frequent offenders can be reported and the visibility of their profile reduced as a result, with the aim to "bring some basic manners and decency to the dating app game", according to Snack. And in 2019, Bumble launched a fleet of pedicabs in New York City emblazoned with the slogan "NO GHOSTING ON BUMBLE", as part of a campaign to nudge its users to be more upfront when the spark fizzles out.

HELLO WORLD/GETTY IMAGES

Sometimes, you think you are in a meaningful relationship, but then you are cut off without notice

> ***"Ghosting is a form of social rejection, which activates the same brain regions that respond to physical pain"***

This painful fallout can perhaps be explained by inbuilt quirks of our brain. A "peak-end" memory bias means we assess an experience based on its intense moments and its end. This was best demonstrated by psychologist Daniel Kahneman and his colleagues in 1993 when they asked people to hold their hand in painfully cold water for 60 seconds and then asked them to do the same for 90 seconds – this time, the water temperature gradually increased during the extra 30 seconds. When asked which trial they wanted to repeat, a significant majority chose the longer experience. The duration of the pain mattered less to people than the way the pain finished. Endings matter.

For my friend and others, a lack of closure can also make ghosting uniquely difficult. When someone stops communicating with you, it could mean that they have had an accident, that you have unknowingly offended them or that they have fallen for someone else – you just don't know. A 2020 survey by researchers at Erasmus University Rotterdam in the Netherlands of 328 daters using mobile apps found that 14 per cent "specifically mentioned they needed closure in order to move on from [their] ghosting experience".

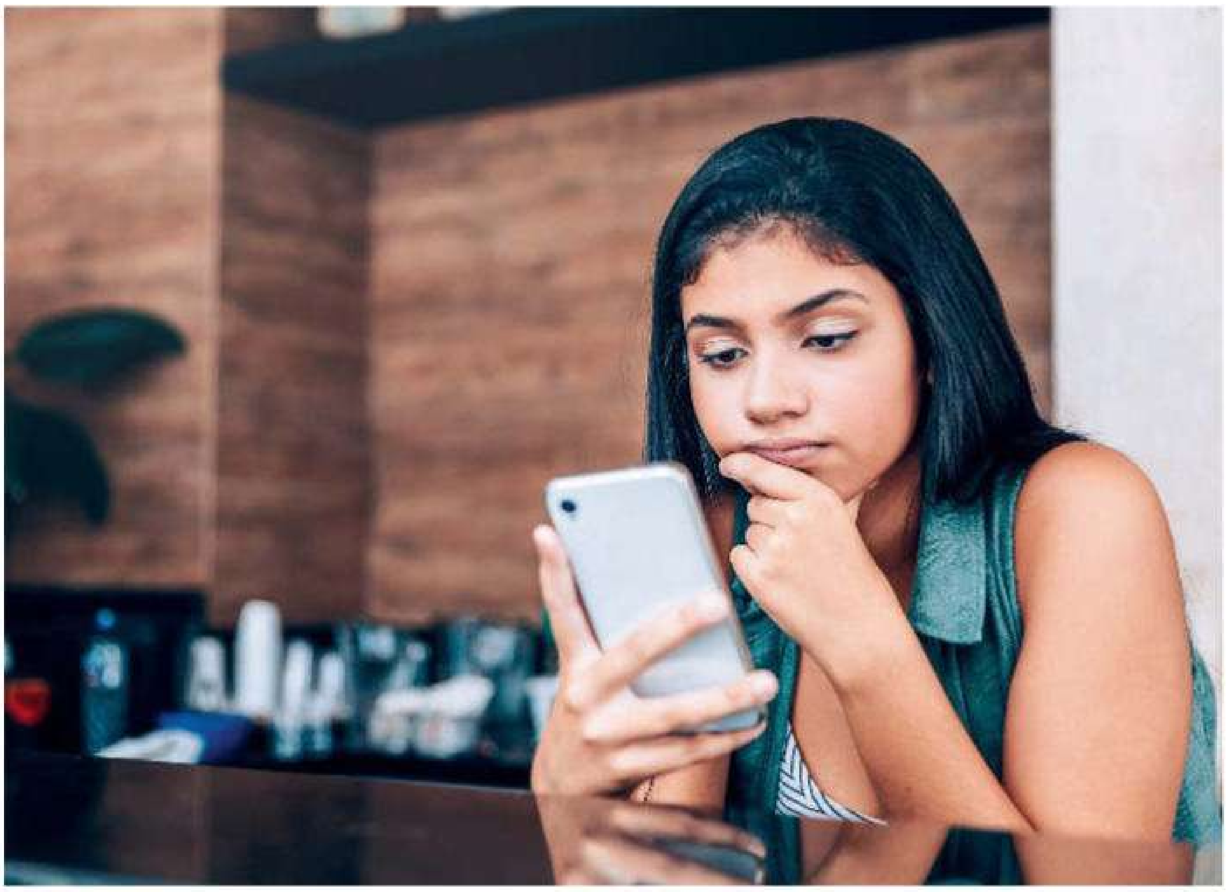
A need for cognitive closure was first identified in the 1990s by social psychologist Arie Kruglanski at the University of Maryland, and relates to a desire for definite knowledge about situations we are in. "It is an essential need for us for reaching judgements and undertaking decisions," he says, and a lack of closure can result in an "upsetting, troubling type of uncertainty".

The need to know

Uncertainty is unpleasant for many people. For instance, a 2016 study by Archy de Berker at University College London and his colleagues found that uncertainty is significantly more stressful than certainty when it comes to impending pain. The researchers monitored 45 volunteers as they played a game in which they were administered small electric shocks. When individuals knew they had a 50 per cent chance of receiving a shock, they experienced more stress than those with a 100 per cent chance. "It turns out that it's much worse not knowing you are going to get a shock than knowing you definitely will or won't," de Berker concluded at the time. The same might be true for the end of relationships.

On top of this, Kruglanski says ghosting can damage our need for significance. "Once somebody ignores you – you're not even worthy of a response – it's a huge blow to one's sense of social worth," he says. We have a fundamental need for social approval and Kruglanski fears that repeat instances of ghosting could have a cumulative effect on someone's self-worth. "Everyone seems free to ghost you, and therefore you must not be worth very much," he says.

Yet Kruglanski also stresses that not everybody has the same need for closure or significance. Some individuals are more tolerant of these factors. Recent research also shows that your beliefs about the world influence your attitude to ghosting. A study led by Gili Freedman at Dartmouth College in New Hampshire found that people with "stronger destiny beliefs", such as a belief in soulmates, were more likely to think that ghosting was acceptable, due to the idea that "some things just aren't meant to be". ›



COKADA/GETTY IMAGES

The uncertainty of not knowing can be hard cope with

> **“You’re not worthy of a response. It’s a huge blow to one’s self worth”**

Still, now that ghosting is common, it may become easier to deal with. It is impossible to say whether someone on the wrong end of a break-up in the days of the Wild West felt more pain than a ghostee today – and that is partly because people back then didn’t have a neat term that could describe and categorise their experience. Vilhauer believes that ghosting was more painful back when she first started researching it than it is now because people weren’t expecting this behaviour. “It was really damaging to [my clients’] self-esteem because it felt like something they were experiencing that no one else was experiencing,” she says.

Kruglanski says the invention of the term ghosting in itself has helped people cope. It was coined by writer Hannah VanderPoel in 2014, but popularised in 2015 when rumours circulated that actress Charlize Theron broke off her engagement with Sean Penn by simply ignoring his calls and texts. “Labelling it as ghosting provides a solution,” says Kruglanski. “In the past, you didn’t know what to attribute it to. Now you say: ‘Ah, she’s ghosting. Too bad that she’s that kind of person.’ ”

But what “kind of person”, exactly, is a ghoster? Last year, a study by Peter Jonason at the University of Padua in Italy and his colleagues linked ghosting with the so-called dark triad personality traits of psychopathy, Machiavellianism and narcissism. They showed that people who had ghosted someone in the past were more Machiavellian and psychopathic than those who hadn’t.

Dark triad traits

While it might be comforting to think that everyone who ghosted you has psychopathic traits, the reality isn’t that simple. “Not everyone who ghosts is high in the dark triad,” says Jonason. He also notes that those who are low on these traits are less likely to be drawn to short-term relationships and casual sex, so arguably have less opportunity to ghost.

People also ghost for a variety of reasons, not always self-serving ones. The 2020 survey by Erasmus University Rotterdam researchers found that 16 per cent of people ghosted because they didn’t want to hurt the person they were rejecting, while 8 per cent felt forced to ghost because they feared their date would become abusive if directly rejected. Research has also repeatedly found that ghostees and ghosters aren’t distinct. “When people have been ghosted, they seem to find it easier to ghost somebody else,” says Vilhauer.

If ghostees then go on to ghost, have we entered a vicious downward spiral, where technology is eroding our empathy and ruining our relationships? Vilhauer fears that ghosting can make it harder for people to be vulnerable, which in turn can make it harder to form meaningful relationships. However, at the moment there are no studies linking increased ghosting with a decrease in empathy.

Still, there are consequences to ghosting and it isn’t the case – as some ghosters might tell themselves – that it is an easier, kinder way to end a relationship than direct rejection. “The emotional reaction definitely felt outsized to what I would rationally expect,” my friend says of her ghosting experiences. “I promise you, it’s better for everyone involved to just say: ‘No thanks. See you around.’ ” ■

Amelia Tait is a freelance journalist based in London

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Stargazing at home

Spot the future North Star

The heavens wheel above us, but at least we can rely on the North Star to provide some stability, right? Afraid not, says **Abigail Beall**

Abigail Beall is a feature editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

Your eyes
Stargazing software like Stellarium (optional)

ONE of the most iconic stars in the northern hemisphere is Polaris, also known as the North Star (pictured). If you can spot this star, you will always know which direction is north, because it is a steady point of light in a changing sky. No matter where you are in the northern hemisphere, it will never move. Or will it?

The North Star hasn't always been, and won't always be, Polaris. At the moment, it is our North Star because of the tilt of Earth: the north pole faces the same direction in space – towards Polaris – even as Earth moves around the sun and turns on its axis. In the same way, the south pole keeps facing the Southern Cross.

But slowly, over thousands of years, Earth's tilt – which is at 23.5 degrees from its plane of orbit around the sun – moves. This is a process called axial precession. You can think of it like a spinning top: Earth is spinning on its axis, but the direction in which it is tilted is also moving around in a circle, in a much slower process. It takes 26,000 years to complete a full circle. The extent to which Earth is tilted also changes, too, by a couple of degrees.

In 12,000 years, the North Star will no longer be Polaris, but a star called Vega. At the minute, Vega can be seen from most places in the world, so anyone can find the North Star of the future. It is one of the brightest stars in the night sky, and sits in the constellation Lyra.

In the northern hemisphere, look north-east as soon as the sun has set. Vega will be the brightest star near the horizon. A few hours later, by around midnight, you will see three bright stars making a triangle shape in the east, near the horizon. This is called the summer triangle. Vega will be the furthest of these from the horizon. Vega is a summer star in the northern hemisphere, so look north-east any evening in May and you will see it.

IGORDABARI/ALAMY

In the southern hemisphere, it is a little trickier to spot. You will have to look quite late at night as it will rise in the north, 3 to 4 hours after midnight, but exactly when will depend on your latitude. Use a planner such as Stellarium to see when Vega will rise in your area.

Vega isn't the only future North Star. As Earth's tilt moves in a full circle, the north pole will face each point in the sky along that circle at some point in the future. Some of these regions contain no stars at all.

After Vega, Gamma Cephei, a star in the constellation Cepheus, will be the North Star.

Alderamin, the brightest star in Cepheus, will have a go a few thousand years later. Cepheus isn't a prominent constellation, but it sits next to Cassiopeia, the W or M-shaped constellation, in the sky.

And what goes around comes around: 26,000 years from now, Polaris will be the North Star once again. ▮

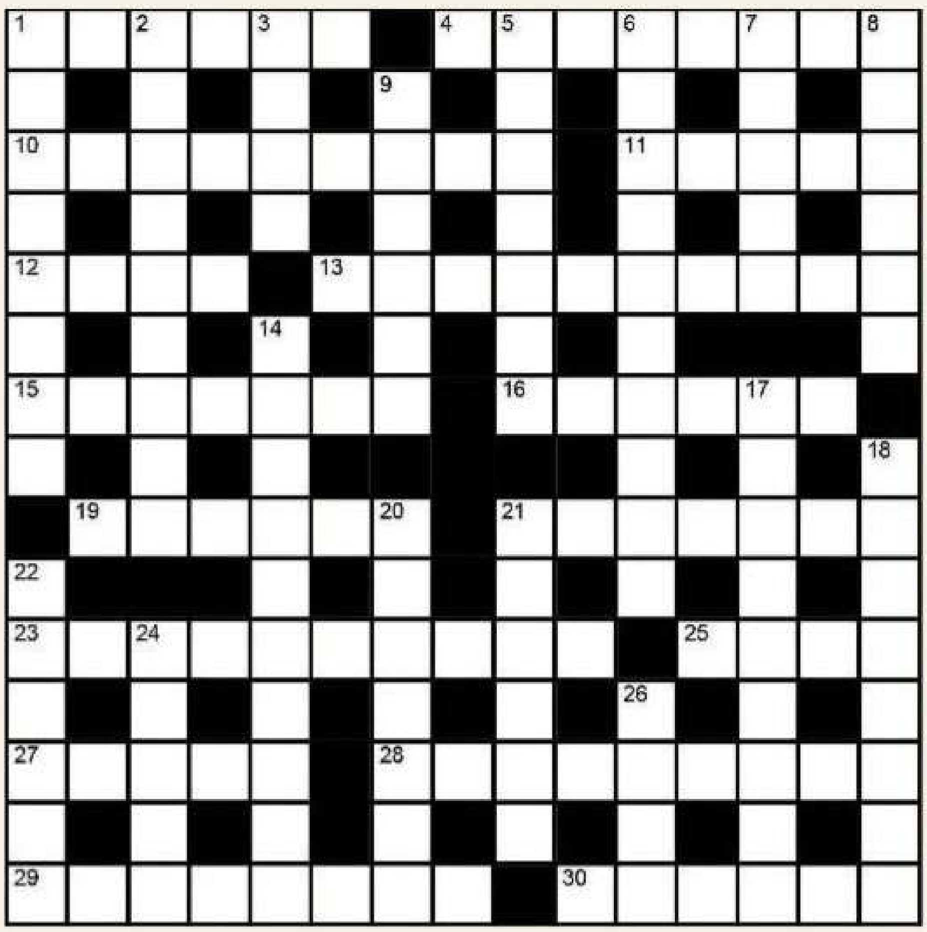
These articles are posted each week at newscientist.com/maker

Stargazing at home appears every four weeks

Next week

Science of gardening

Quick crossword #106 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Polysaccharide produced by plants (6)
4 Workbench clamp (8)
10 Deriving from observation or experience (9)
11 Wood pulp product (5)
12 Rear appendage (4)
13 Erwin ___, German ornithologist (10)
15 Study of flying saucers, etc (7)
16 Prescribed quantity of medicine (6)
19 Hard-setting binding material (6)
21 ___ problem, ethical dilemma hypothesised by Philippa Foot (7)
23 ___ fault, tectonic boundary between the Pacific and North American plates (3,7)
25 Soft clay mineral, $Mg_3Si_4O_{10}(OH)_2$ (4)
27 "Any sufficiently advanced technology is indistinguishable from ___" – Arthur C. Clarke (5)
28 2010 sci-fi film directed by Christopher Nolan (9)
29 One of the four nucleobases in DNA (8)
30 Of an unborn baby, feet-first (6)

DOWN

1 Continuum such as a rainbow (8)
2 Mineral such as hornblende or gedrite (9)
3 European Organization for Nuclear Research (4)
5 ___ rape, yellow-flowering crop (7)
6 Sunken landform (10)
7 α (5)
8 Kind of flycatcher (6)
9 Starfleet officer Montgomery Scott, informally (6)
14 Nicolaus ___, Renaissance astronomer (10)
17 Coat with zinc (9)
18 Spring flower in the family Asparagaceae (8)
20 Twisting (7)
21 Semi-conscious state (6)
22 Unable to understand signs or symbols (6)
24 Hours of darkness (5)
26 Strut or rib (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #148

1 A molecule that is neutral overall but has both positively and negatively charged functional groups is known as a what?

2 In what year did NASA's New Horizons probe fly by Pluto?

3 Cholecalciferol and ergocalciferol are compounds in which vitamin group?

4 What name is given to the horn-like structures on the heads of giraffes and male okapi?

5 Which 20th-century British physicist attended the same primary school as Archibald Leach (later known as actor Cary Grant)?

Answers on page 55

Puzzle

set by Rob Eastaway

#164 Sum thing wrong

Amira presented her homework to her teacher:

2797
+2367
=4654

"Wrong, Amira, please check your working."

"I promise you it is right. It is just that I have used a code. Every digit used represents a different digit, and the same digit is always represented by the same 'wrong' digit. For example, maybe I replaced all the 6s with 4s. Or maybe I did something else..."

"You are giving me a headache, Amira".

What is the correct sum?

Solution next week

Aitch issue

Why do Hs get dropped in some languages? Greek mythology is full of names starting with an H, yet the H sound is dropped in modern Greek, and also in Italian, French and Cockney English.

Jo Murphy
Waikanae, New Zealand

It takes regular, even breathing to talk out loud. The letter H is aspirated. This means it requires conscious breath control, a little punch of air, to say "H" even if we aren't aware we are doing this.

Try saying "I want some herbs" then "I want some 'erbs". You will then be aware of that extra breath, however slight. It is easier for an Italian person to say "'erb" in the middle of (often fast) speech.

Bob Ladd
Edinburgh, UK

The question treats "H" as a special case, but there is no real basis for this. Some languages have H sounds and some don't, but you can say the same about most sounds: English and Albanian have "TH" (as in "theme"), but French and Russian don't; German and Turkish have "Ü", but English and Polish don't; most European languages have "P", but Arabic doesn't. The reasons for these omissions are obscure: partly historical (languages can lose sounds as well as gaining them), and partly just the way things are.

> **"'H' has a special status as a social marker. The ancient Roman poet Catullus made fun of someone who dropped his aitches"**

The special thing about H mostly concerns European spelling. Latin had an H sound that disappeared from its modern descendants (French, Italian, etc.), but because spelling is often conservative, in many European languages, H is written even though it isn't pronounced. This is also true of lots of other letters, especially in English and French.

So to a native English speaker, the absence of an H sound in French or Italian is noticeable in a way that the lack of "Ü" in English or Spanish isn't, because as a foreign learner, you have to remember that "H is silent".

In England, "H" also has a special status as a social marker, as in the questioner's reference to Cockney, an accent associated with working-class Londoners in which Hs get dropped or added unnecessarily. All languages have social markers, but the fact that "H" plays this role in England may make the silent H in Greek, Italian or French seem especially significant.

Incidentally, "H" had the same social function in classical Latin: one poem by the ancient Roman poet Catullus makes fun of a certain Arrius, who added H sounds to words unnecessarily.

"H" is actually a bit unusual because, in many languages, it occurs only at the start of a syllable, but that is a separate topic.

CULTURA CREATIVE RF/ALAMY

How can the slipperiness of a slide vary so much from one day to the next?

This week's new questions

Sliding scale **In children's playgrounds, I am always confounded by how the slipperiness of the same slide can vary hugely throughout the day, and on different days. What factors influence this?** ***Richard Webb**, Southsea, Hampshire, UK*

Vowel-less **Why are there more consonants than vowels in alphabetic languages?** ***Sasha Belenky**, San Diego, California, US*

Great gusto

Why, or how, do winds gust?

Mehmet Karatay
Newtonmore, Highland, UK

Gusts are turbulence that can be caused by obstacles in the wind's path. This is why gusts are more common in cities with tall buildings and in the mountains, despite mean wind speed being lower over land than sea.

When winds blow over the sea, the smoother surface keeps the wind speed more consistent over a period of time. If there is an increase, it tends to be a squall, which, unlike a gust, lasts in the order of minutes.

Strong gusts are common on the lee (sheltered side) of mountains and these can be very powerful. In the Great Sheffield Gale of 1962, the UK city of Sheffield, which was on the leeward side of the Pennine hills during an intense storm, was devastated by gusts of up to 156 kilometres per hour.

Mike Follows
Sutton Coldfield, West Midlands, UK

Winds are ultimately driven by the sun. They are caused by air moving down a pressure gradient from a region of high pressure to one with lower pressure.

The temperature at any point on Earth's surface varies with time. The air above a warmer patch will expand, becoming less dense, and is then replaced by cooler, denser air – something we might perceive as a gentle breeze. The patches of warm surface depend on location (latitude, aspect of slope etc.) and the time of day, due to the position of the sun.

Add to this Earth's uneven topography – even trees will affect the wind – and it is easy to visualise that the atmosphere is turbulent, so the speed and direction of the wind at any point can fluctuate. Pressure patterns are constantly developing and moving around, which leads to a complicated interaction of winds blowing from different directions.

Gusts are more likely on a windy day and often occur when wind blows around obstacles, like trees and buildings, which generate vortices. The same applies to mountainous terrain, particularly ridges or escarpments, where gusts can be hazardous. Anyone in the vortices experiences the wind changing speed and direction.

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Tom Gauld
for New Scientist

I SPEND MY DAYS DESPERATELY SCOURING A BEWILDERING UNIVERSE FOR TINY FRAGMENTS OF ORDER, HOPING AGAINST HOPE TO GLIMPSE A PATTERN IN THE CHAOTIC VOID. EXCEPT TUESDAYS, WHEN I DO YOGA AND HAVE LUNCH WITH MY MOTHER.

Gusts last only a few seconds and can be reclassified as squalls when the increased wind speed lasts more than a minute.

The fastest recorded wind gust was 408 kilometres per hour at Barrow Island, Australia, on 10 April 1996 during Tropical Cyclone Olivia. Higher speeds have been recorded by Doppler radar, but only wind speeds recorded using an anemometer are counted officially by the World Meteorological Organization.

Keith Ross
Villembits, France
People often think, falsely, that air heated by the sun rises, allowing colder air to take its place – a typical convection current. While it is correct that wind power is driven by the sun, hot air doesn't rise, not by itself anyway. It is cold air (which is denser) that sinks, pushing the less dense hot air out of the way, thus causing gusts.

And air isn't heated directly by the sun, as it is transparent to visible light. The sunlight is absorbed by the planet's surface, which gets hot, thus heating the air in contact with it. The colder air above now pushes this out of the way to become heated itself.

> **"Gusts are more likely when wind blows around obstacles like trees, buildings and mountains, generating vortices"**

Garry Trethewey
Cherryville, South Australia
When I stand near a stream, I see little whirlpools forming at protruding rocks, and those whirlpools detach and move away from the source. Similarly, when I stand on a hilltop on a windy day, looking across the valley, I see a small area of wildly gyrating trees among the stationary ones, and this patch of gyration moves across the hillside.

When fluid flow is interrupted, by a solid or by other fluid bodies, turbulence forms. From a distance, we can see its results, but if we are in it, we feel a sudden gust.

Harking back to my hilltop, I have expected (and hoped) to see a particular tree first be blown one way, then the other as the "whirlpool" passes, but with the wild gyration I haven't been able to make this out.

Menthol block

Do menthol nasal decongestants still work if you can't smell them?

Tim Lewis
Narberth, Pembrokeshire, UK
Several studies have shown that menthol has no effect on the opening of blocked or restricted nasal airways.

Menthol stimulates TRPM8 receptors in the nose, which are also activated by cold temperatures, giving a sensation of increased airflow. These are different from smell receptors (called GPCRs), so both menthol smellers and non-smellers should be aware of this cooling sensation.

Menthol doesn't unblock your nose, it just makes you think it does. ▮

Answers

Quick quiz #148
Answers

1 A zwitterion
2 2015
3 Vitamin D
4 Ossicones
5 Paul Dirac

Cryptic Crossword #81 *Answers*

ACROSS 7 Trial and error, **8** Flagella, **9** Titi, **10** Guanaco, **12** Kayak, **14** Adept, **16** Formula, **19** Slum, **20** Alienate, **22** Stalking horse

DOWN 1 Oral, **2** Jargon, **3** Laplace, **4** Addax, **5** Protea, **6** Contrail, **11** Undulate, **13** Foliage, **15** Pimple, **17** Manioc, **18** Tapir, **21** Tusk

#163 Down for the count
Solution

The contestants managed to get the answers 1, 2, 5 and 9. Here are possible routes to those numbers.

(((100,000 + 10,000) ÷ 1000) – 100) ÷ 10 = 1

((100,000 ÷ 10,000) + (1000 ÷ 100)) ÷ 10 = 2

10,000 ÷ (10 x ((100,000 ÷ 1000) + 100)) = 5

10 – (100,000 x 100) ÷ (10,000 x 1000) = 9

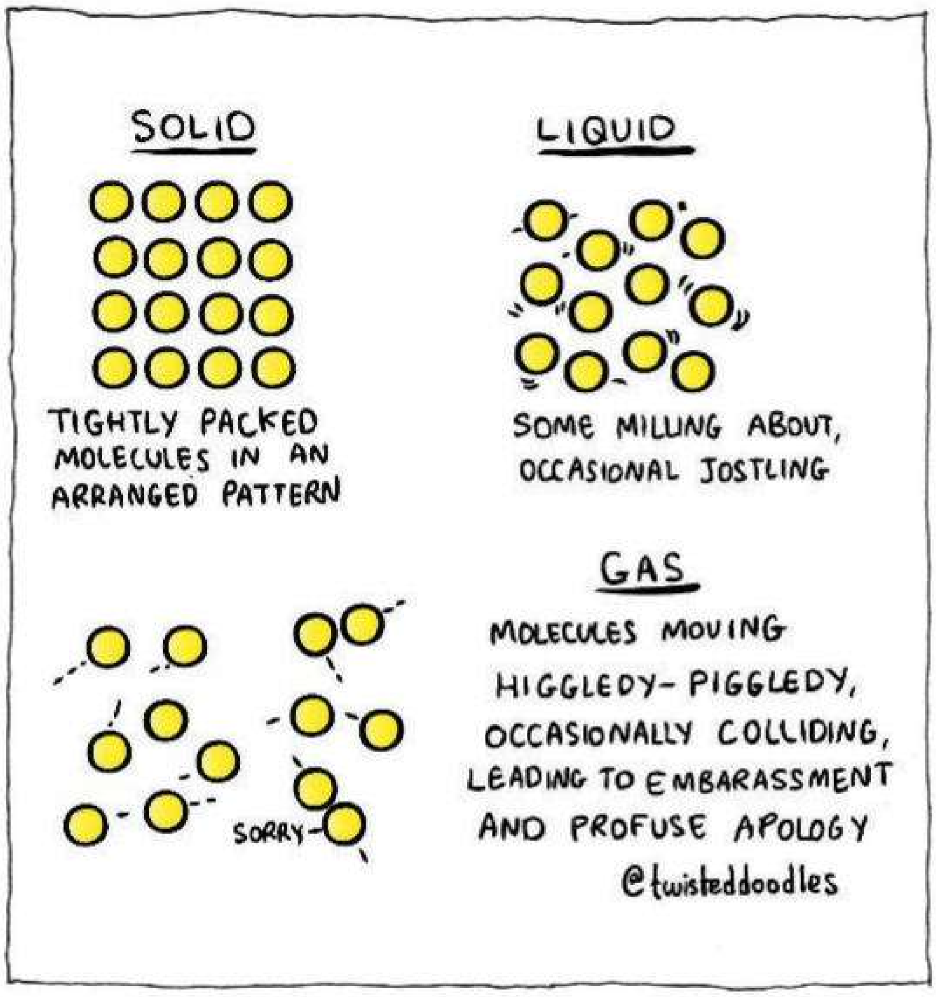
Quaking on our bikes

Feedback doesn't live in great fear of earthquakes. The last significant tremor in our neck of the woods – a 4.3-magnitude shocker that hit Folkestone, UK, in 2007 – was, according to one eyewitness, like "someone was at the end of my bed hopping up and down". This is how it felt the last time the earth moved for us, too, although admittedly that was even further back.

Still, you can't be too careful, and the past couple of years have taught us nothing if not the value of the precautionary principle, although possibly not even that. Anyway, this is why we want an earthquake-resistant bicycle saddle of the type Kristen McAteer alerts us to on Kickstarter. It strikes us as a jolly good idea, not least because physicists still struggle to intuit how a bicycle stays upright at the best of times.

We note the saddle cushion is also 100 per cent leak-proof and easy to dry, important qualities when dealing with the emotional fallout of a sudden cyclequake. It is also 99 per cent antibacterial, the sort of claim that makes us think the surviving 1 per cent are left rubbing their hands.

Twisteddoodles *for New Scientist*


SOLID
TIGHTLY PACKED MOLECULES IN AN ARRANGED PATTERN
LIQUID
SOME MILLING ABOUT, OCCASIONAL JOSTLING
GAS
MOLECULES MOVING HIGGLEDY-PIGGLEDY, OCCASIONALLY COLLIDING, LEADING TO EMBARASSMENT AND PROFUSE APOLOGY
SORRY
@twisteddoodles

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Consideration of items sent in the post will be delayed

Measured response

Completing a half-marathon pushing a buggy containing 4-year-old quintuplets, as runner Chad Kempel did at the Oakland Half-Marathon in California in March, must count as a feat of stamina and endurance. Although possibly not as much as having 4-year-old quintuplets. Our respect is only increased by learning in *Runner's World* that the load amounted to "108kg – roughly the weight of a baby elephant calf".

Duncan East asks whether the baby elephant is a recognised subunit of the standard elephant, like a centiphant or a milliphant. We make it about 18 milliphants, suggesting related but rival systems, much as the US and the UK can't agree on the size of a pint.

On this subject, apologies to regular readers for our recent story on the errant mass of the W boson, which failed to include the crucial information from the Fermilab press release that the observation corresponded to "measuring the weight of an 800-pound gorilla to 1.5 ounces". That's a tad over 3.3 babyphants to within 7 microphants, and thanks to Ian Stopher for flagging this omission.

Keep whatever distance

Meanwhile, Neil Williams gleans from a social distancing sign at a botanic garden in Australia that 1.5 metres is equivalent to 10 waratah flowers, three water dragons, 5 white-winged choughs, 7 secateurs or 1 tree fern frond.

And a partridge in a pear tree, we carol reflexively and aseasonally. As we often do in these instances, we find ourselves wondering just how big these things are. Neil points out that within a few dozen secateurs of the sign, resolutely non-normative water dragons were varying in length from around two-thirds of a tree frond right down to a tenth of a white-winged chough. This sounds like a variable social distancing policy just as we practised it in the Before Times, only choosing a safer distance from any scissorhands wielding seven secateurs.

Dark rental agreements

We like it when Feedback readers take things into their own hands, leaving ours free to do the devil's work. So we are pleased that Marthinus Roos has calculated that combining just five characters should be enough to generate a unique URL for all of the world's websites, given 104 keys on a standard keyboard.

This sets our hands fair racing across our keys to head off those of you who would take it upon yourselves to write in pointing out that some of these are function keys, the numbers appear twice, etc., etc. Marthinus is moved to his observation by encountering the URL of a car rental agreement that was 1400 characters long – enough, he points out, to generate a unique URL for every atom in the universe.

Or perhaps, he speculates, in some unobserved corner of the cosmos, there are simply unimaginable numbers of car rental agreements. Around 10^{1358} per atom in the universe should be enough to justify the 1400-character thing. If so, we might have found what is making up all that missing matter and energy in the universe.

Koons to the moon

No sooner had we arched an eyebrow about an auction of NFTs, digital widgets often mistaken for art, that had been blessed in space (2 April), than we learned that artist Jeff Koons intends to shoot actual art to the moon aboard a private lunar lander called Nova C. There, we discover, courtesy of an article in *The Art Newspaper* sent in by Michael Zehse, his sculptures "will be permanently housed in a transparent, thermally coated cube".

Given the lack, we presume, of a lunar exhibition-going public, we are puzzled as to why Koons would go to these lengths, until we read in the article's subhead that "corresponding digital renderings of the lunar-bound works will be sold as NFTs, obviously". Ah.

Koons's art wouldn't be a first: a 9-centimetre statuette called *Fallen Astronaut* was left by the Apollo 15 mission in 1971 to commemorate those who had died during the US and Soviet space programmes. This caused a stir when the sculptor Paul Van Hoeydonck tried to sell limited-edition reproductions, violating NASA's policy forbidding commercial exploitation of space. Oh the times, the habits. ▮

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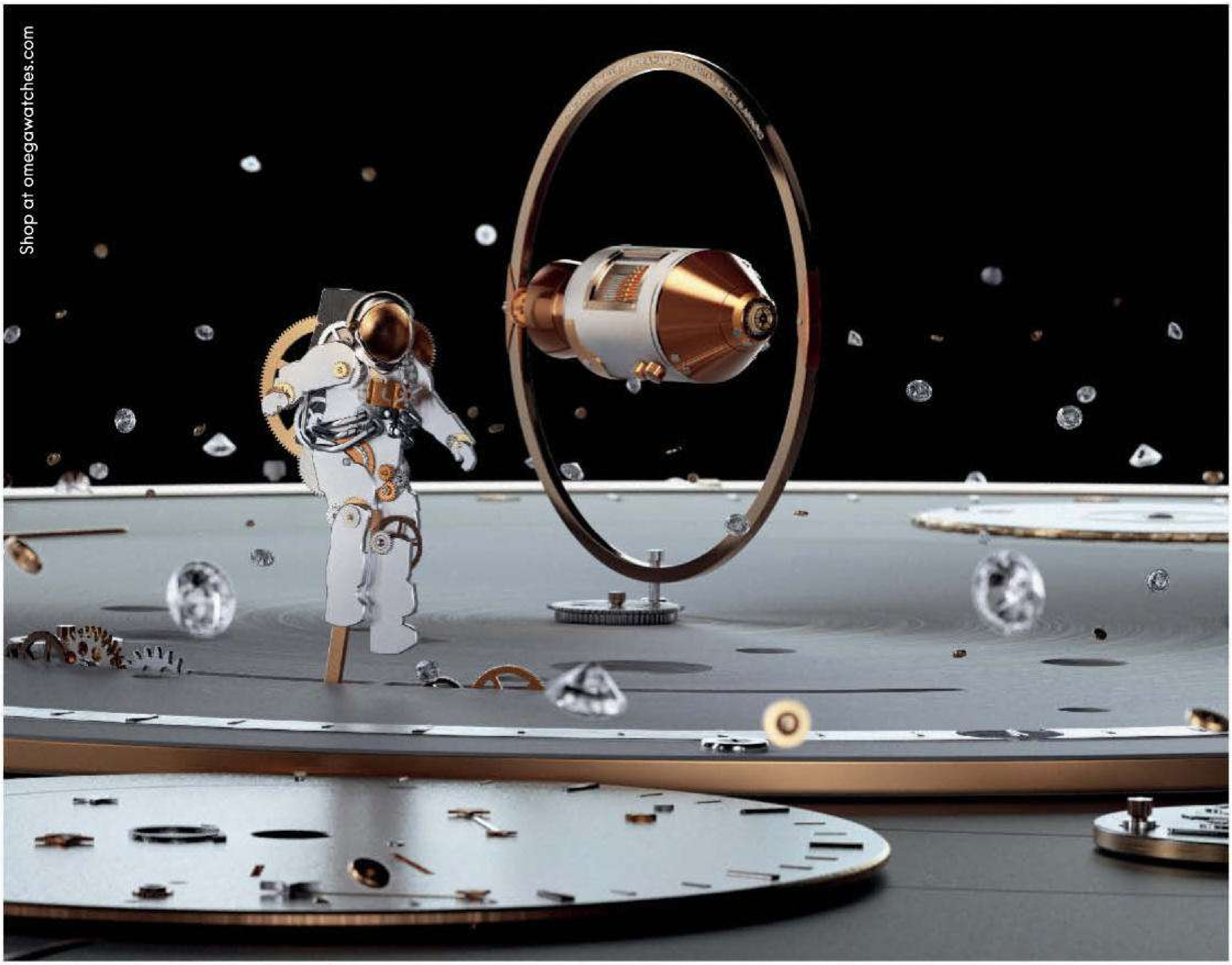

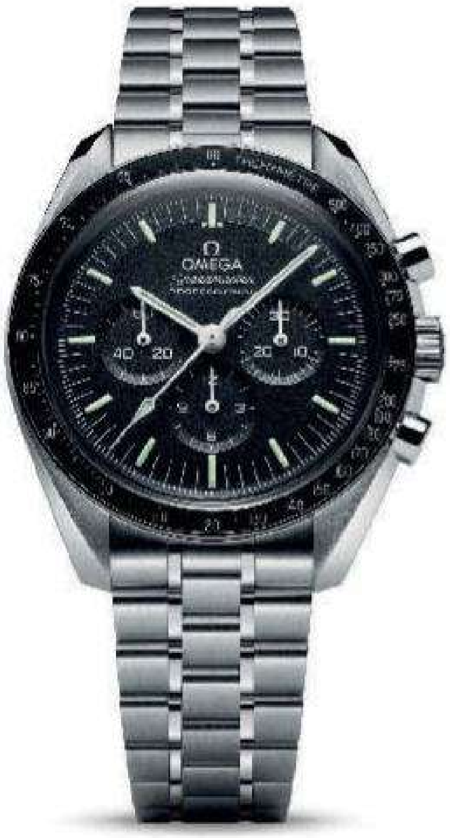
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